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TESI DI LAUREA

"THE FEMALE PARTICIPATION TO THE LABOUR MARKET AND THE ANALYSIS OF THE STRATEGY TO SOLVE THE TRADE-OFF BETWEEN FAMILY AND WORK: THE ROBUSTNESS OF THE SIMULATION MODEL"

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Introduction

"*Enable every woman who can work to take her place on the labour front, under the principle of equal pay for equal work. This should be done as quickly as possible*" (Mao Tse Tung, 1955).

This quote resumes the fundamental topic of our final dissertation that, in its aim and its used instruments, could be analysed through four fundamental guidelines: the women role in the society, the analysis of a potential relationship between the part-time opportunities and the female participation to the labour market, the Netlogo simulation instrument and the possibility for testing the model robustness.

First of all, we mentioned the choice about the matter of interest: we choose the women category not only because of our gender but also because we believe that, especially in this period of economic drop, a re-organization of the productive system, through radical changes (such as those of a revolution in the female labour market participation) must be occurred.

Particularly related to the last point, Institutions have to take in consideration the female role both in the economic and familiar context. Women, along the entire historical context, have been represented a key feature in characterizing the sociological context of the considered period, from the *matronae* of the Roman culture until the suffragettes of the French Revolution. Although the claim, typical of these last years, for a revolutionary female role, the woman carries on being the key figure in managing the familiar duties and this aspect has to be seriously considered during the definition of the emancipation process. There have to be individuated suitable instruments in order to allow woman to realize herself: her working fulfilment cannot be unlinked to her private dimension. Then, in analyzing the female contribution to the labour market, the conciliation instruments (both formal and informal ones) have to be analyzed. Among them (child benefits, parental leaves etc.), part-time opportunity is that of greater importance, considering it no longer as a segregation mechanism that exiles women to low qualified positions, but as source for the female gender in conciliating procedure.

How can proving the conciliation instruments effectiveness be possible?

Whereas usually the economic literature approaches to this topic with traditional instruments, (such as econometric investigations) we opted for an innovative mean, the simulative approach. In doing this, we choose Netlogo program substantially for two reasons: we knew managing ourselves with it, during the course of Simulation Model for Economics and it gives an immediate and intuitive idea of the obtained results. It allows creating agents that, given a set of predetermined variables, interact autonomously between each others. In this particular context, we choose two agents categories: firms and women. The first one represents the labour market supply, the second one the demand side: given the part-time level disposable in the market and known the female preferences concerning the informal and informal childcare coverage, through the interaction, we want to define the level of aggregate wealth produced along each year, a sort of immediately comparable measure (about the connection between the part-time availability on the labour market and the aggregate wealth produced) that will be used in comparing the final observations.

Independently from the obtained results, the relationship among the involved variables is not as obvious as it can appear. Properly from the complexity of the relationships among the chosen parameters arises the need for a control on the robustness of the obtained results: the last part of this document, indeed, will be focused on evaluating them through the usage of a specific program, BehaviorSearch. It, thanks to the exploitation of the genetic algorithm method, tries to individuate the optimal combination of the parameters used in the simulation, once inserted, as a benchmark for the evaluation, a chosen variable.

In Chapter 1, we will resume all the available contributions found by exploring the economic literature about our topic. We will start from some considerations about the evolution of the female presence in the socio-economic context of the two last centuries, taking into account its strict relationship with the achieved education level and the possible female participation target that has to be reached, in accordance with the European standards.

We will proceed in describing the possible existence of a sex segregation phenomenon: easier speaking, we will talk about the fact that, even if the female participation

increases, it continues to be exiled to low-qualified positions, accompanied by a relevant wage gap between male and female workers.

Then, we will analyse the relationship, not as obvious as it can seem, between the female presence in the labour market and the changes in fertility rates, especially in the last years. To be more precise, in the analysis of the Italian context, we inserted also a contribution about the Italian labour market, considering both the institutional context and the population distribution.

It seems reasonable an implementation of this initial picture through some considerations about family-friendly policies, such as both formal and informal childcare, child benefits and parental leaves, also considering that, in the model we will create, we will consider not only the part-time availability, but also other important conciliation strategies, such as formal and informal childcare. A greater space is reserved to the part-time literature, particularly with the purpose of analysing the phenomenon in the Italian context, its juridical framework and the economic perspectives coming from its implementation.

In Chapter 2, we will focus on the sociological interpretation of the phenomenon. Undoubtedly, the female condition, even before having an economic relevance, is a typical sociological topic. We will report an historical overview of the female figure starting from the *dominae* of the productive familiar unit (at the end of the nineteenth century), to come to the emancipated worker condition characterizing the post-war years. Once defined woman outside the labour market (the housewife figure), we will deal with the time conciliation problem, reporting a description of the role of part-time as an instrument able to conciliate the female participation to the family and her economic independence. As previously done from an economic point of view, we will analyze, also in this case, the sociological impact of the grandparents contribution, interpreted as the most relevant provision of informal childcare, by considering not only the phenomenon in itself but also its possible implications in term of relationship between the involved agents. To do a further step, we will take into account the sociological features of the labour market (both from the demand and supply side), considering its possible connection with the attained education level, considered contemporaneously as an investment and as a cost.

Once defined the literature background, we will carry on with a description of the technical instruments we will use in our simulation process.

In Chapter 3, on one side, we will provide the Agent-based Model definition as a model in which autonomous agents, interacting among themselves, simulate particular horizons; on the other, we will describe the relevant advantages and disadvantages of its usage.

In Chapter 4, we will describe our initial model created during the university career and representing a milestone for our further development about this topic, becoming the core of our thesis dissertation. The discussion is focused, firstly, on the code analysis and, secondly, on the most relevant results derived from the model.

Chapter 5 represents the substance of our work, introducing our simulation model. First of all, we will insert a description of the original pool of data, obtained thanks to the contribution of the LABORatorio Revelli, and its subsequent manipulation useful to create a new dataset that we will adopt during the simulation. To be more precise, in approaching to this topic, we will follow the same procedure applied to the previous chapter, describing in details the code features. Furthermore, we will discuss the results arising from our simulation model, putting on evidence the most significant observations, obtained from a particular setup of the fundamental considered variables.

The Chapter 6 refers to the analysis of the robustness of the model. In getting ready it, we have used the BehaviorsSearch program. Standing on the fact that it is based on the genetic algorithm concept, we preferred to treat the argument firstly on a theoretical side, making references to its history and its biological background. We will proceed more deeply in explicating the phases of the implementation procedure, distinguishing between initialization, selection, reproduction, cross-over and mutation. Additionally, we will insert a practical description of the relevant features of the program and about how it is working. Lastly, we will proceed in commenting the

obtained results, adding some references on how the model can be further improved in its efficacy.

1. Women participation in the labour market

Whereas a century ago, women were often excluded from the full exercise of those civil rights which many men enjoyed, and most women never attained the status of full legal adults, now equality is conceivable (..) The respective roles of men and women are still undergoing profound change, in the process transforming the nature of the family, society, culture and politics along with economics and the world of work (from *Women, Gender and Work, ILO, 2001)*.

Analyzing the main features characterizing post-war OECD labour market, we can focus our attention on the "womenization" of the labour force. Whatever countries we refer to, the data show a marked decline in the gender employment gap. This unfortunately does not imply a more egalitarian distribution of payment and roles between men and women.

The view that men's wages will negatively affect women's employment is also consistent with what economist call an income effect, in which the more alternative sources of income family has, the less likely any given member is to be employed. But explaining increased women's employment in terms of a decline in men's wages doesn't fit the evidence very well (from England P., 2005).

Indeed, gender wage differentials are wider in countries with the highest female employment rate. How can we match these two contrasting paths? Probably we can do this with the explanation that at least initially, when female employment rate started to rise, it was necessary to accept greater differential in remunerations.

Especially in the past, men predominated in upper management, prestigious professions and blue-collar crafts; while women numerically predominates professions, such as nursing and teaching.

However, since 1970s, as well as rising participation rate also women's college attendance and graduations have increased relative to males, reflecting in their occupations and earnings.

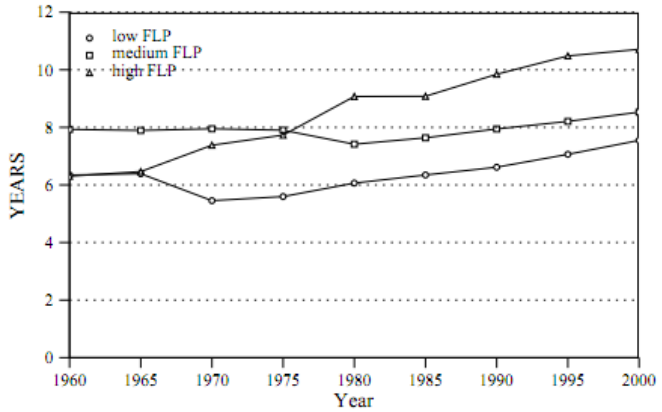


Figure 1.1: average years of schooling of female in low, medium, high participation countries. (Source: Engelhardt and Prskawetz (2002))

Although the general increase in attendance all over the Europe, we have to signal the particular performing path of countries with high participation that jumped from 6 years of formation, around the 1960s, to 11 in the 2000s.

As proved by many recent studies, the changes in women's education affect wage rates as well as wage profiles, with important effects on participation and fertility decisions and on the timing of the events. Particularly referring to the motherhood decision, highly educated women work also during the period surrounding a birth event and therefore education, in some sense, could induce fertility postponement. These results imply that policies aiming at increasing women's education would have a positive effect on labour participation but uncertain effects on fertility, given evidence of a U-shaped relationship between fertility and education (interpreted in terms of the prevalence of income over substitution effects due to education and to the fact that highly educated women have access also to the expensive private childcare system).

We can consider the increase of the female participation in the labour world also at the European level such as a ambitious goal, as demonstrated by the event in Lisbon (March 2000) where the head governments of the European Union subscribe the goal of raising the female employment rate to 60% from 54% in less than ten years.

One year after, The Spring Eu Council in Stockholm implicit admits the risk that a fast track to Lisbon target could increase the gender wage gap.

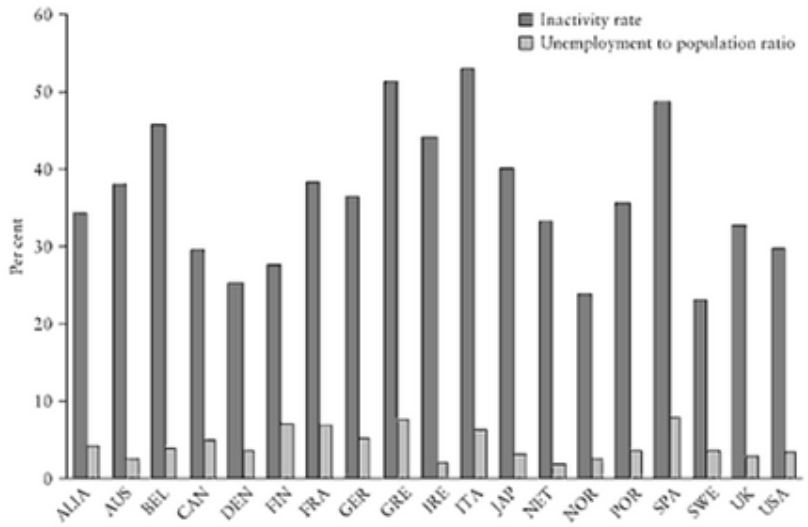


Figure 1.2: Female inactivity and unemployment as per cent of population of working age (Source: Boeri T., Del Boca D., Pissarides C, 2005.)

Additionally, Figure 1.2 shows that in Italy reaching the Lisbon target is particularly ambitious standing on the fact that the actual inactivity rate of our country is, unfortunately, one of the highest in the world (attested around more than 50%).

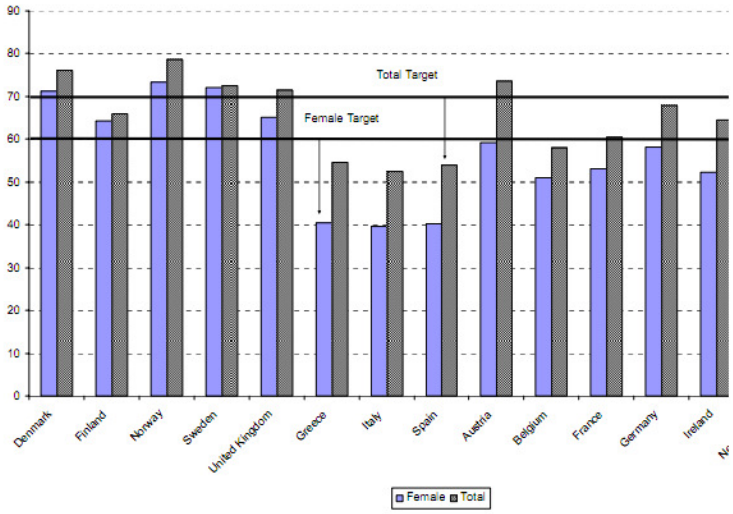


Figure 1.3: The distance from Lisbon: Male and Female employment rate 2000 (Source: Boeri T.)

As shown by "Women at work"[1], it seems to be possible to attain the Lisbon target in Southern Europe by 2010 by freezing all jobs currently held by women until they rich the age of 65. This, however, does not appear feasible at the present, standing from the fact that there is a strongly declining trend in the employment rate related with age; additionally, when women approach for the first time to the work system, they also involve some crowding out effect with respect to groups with a weak attachment to the labour market (as the new entrants with low occupational experience).

"But over time, as women at work acquire more job-related experience they no longer compete for jobs with young people. Female employment eventually complements male employment, encouraging the creation of new job. Contrary to popular wisdom, there is no such thing as a fixed pool that has to be shared by men and women: women at work do not reduce job opportunities for men, although in the short run a steep increase in women employment rate may create some distributional tension. More women at work soon or later contribute to more job creation to everyone's benefit." (from T. Boeri (2005), p. 3).

This female employment could also display a negative relationship with the fertility rate in a Continent where the population is rapidly aging and it could be viewed with respect to the children welfare because their mothers devote less time to their care, particularly when the available jobs in the market are only fulltime.

[1] T. Boeri, D. Del Boca, C. Pissarides (2005), Women at work: an economic perspective, Oxford, Oxford University Press

1.1 Occupational sex segregation

Men predominate in upper management, prestigious professions and blue-collar crafts; while women numerically predominate in professions, such as nursing and teaching. Segregation could be measured with the index of dissimilarity, D, which explains the percentage of either men or women would have to change occupations to render all occupations integrated with the same female percentage as the whole work force. D decreased in most decades, but the decades showing the stronger phenomenon were 1970s and 1980s; indeed, since 1990 declines have been much less steep (from England P., 2005).

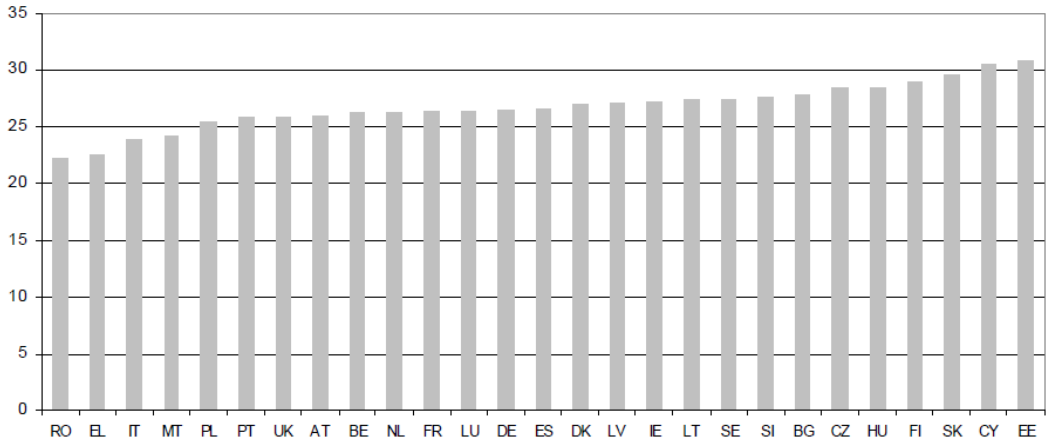


Figure 1.4: Gender segregation in occupation in EU Member States, 2005

(Source: Eurostat)

Debates about the causes of the segregation are often based on the evaluation of both supply and demand side of the labour market. We will discuss in details the features of these two different approaches in next chapters.

Whatever the causes of segregation, the condition could be linked to the pay gap, due to the lower payment for the female labour supply than the male one.

The economists take into consideration many possible explanations for the lower payment of occupations with high percentage of females. One of these is based on the compensating differentials concept, or better on the idea that the full pay consists of both pecuniary and non pecuniary wage, the latter being the disutility derived from

doing the work itself: jobs less hazardous and with a more favourable treatment can be filled with lower wages, *ceteris paribus*. Starting from the fact that the majority of women are more influenced by the non pecuniary aspect, they, probably, would prefer to substitute earnings with amenities, such as more safer and mother-friendly jobs.

1.2 Labour supply and fertility in Europe

Before starting in the analysis of the relationship between the participation rate and the fertility one could be useful inserting a brief explanation of this last measure.

With Total Fertility Rate (TFR) we refer to a measure computed from age-specific birth rates in a given year. It can be interpreted as the average number of children that a woman would have during her life if the age-specific fertility rates prevailed during her fecund life (usually, 15-49). It is useful because includes the most recent information about the topic, but, in the other hand, is not able to record the fertility of actually completed family size.

Two combined effects determine the temporal decrease in fertility rate:

- On one hand, the total fertility rate we are referring before (the quantum effect) has declined,

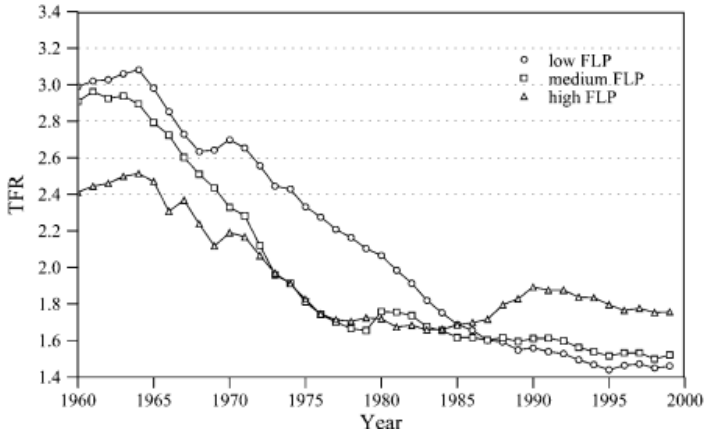


Figure 1.5: Average total fertility rate in low, medium and high participation countries (Source: Engelhardt and Prskawetz 2002)

Going more into details, in the high participation countries the total fertility rate starts to decline in 1970 from 2.19, turning back to 1.79 only in 1990s; in the low participation countries, instead, the fertility rate in 1970s was around 2.72 and declined to 1.4.

- on the other, the age at first child has increased (the tempo effect) and, as a consequence, the number of children per family has reduced over time.

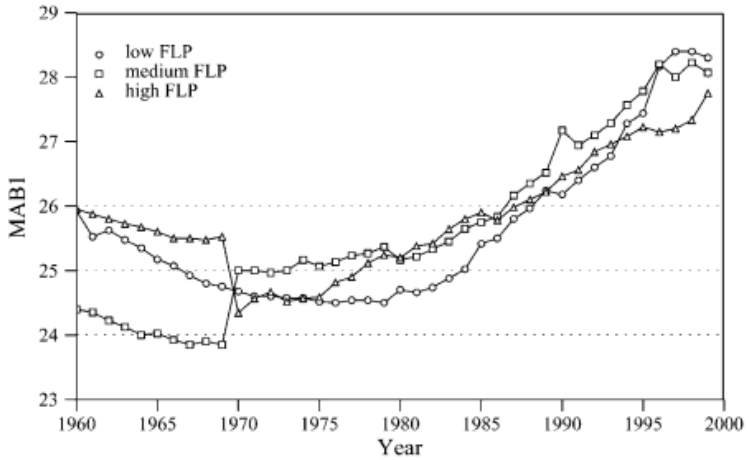


Figure 1.6: Mean age at first birth in low, medium and high participation countries

(Source: Engelhardt and Prskawetz 2002)

Figure 1.6 shows the significance of the postponement of the fertility decision: the average age in the 1960s was in 24-26 range and grew to 28 around year 2000.

A good explanation of both previous effects could be the increased educational level of women: more highly educated women, indeed, are more likely not to have children or to have the first child later.

"Over the last several decades, the labour market participation of married women has increased and fertility rate have declined in most developed countries. The growth of women participation in the labour market carries with it some positive and negative implications for the ability of countries and the European Union itself to meet a variety of social and economic targets. On one hand, the increased number of worker helps to pay pension obligations to current retires, while, on the other hand, the declining population levels make it less likely that the current form of European pension system can be sustained."(from D. Del Boca (2005), p. 124)

In Figure 1.7 the relationship between the fertility rate and participation rate in all European countries is depicted, showing a bad position for Italy (near only to that of countries such as Spain and Greece, characterised by a more difficult economic situation).

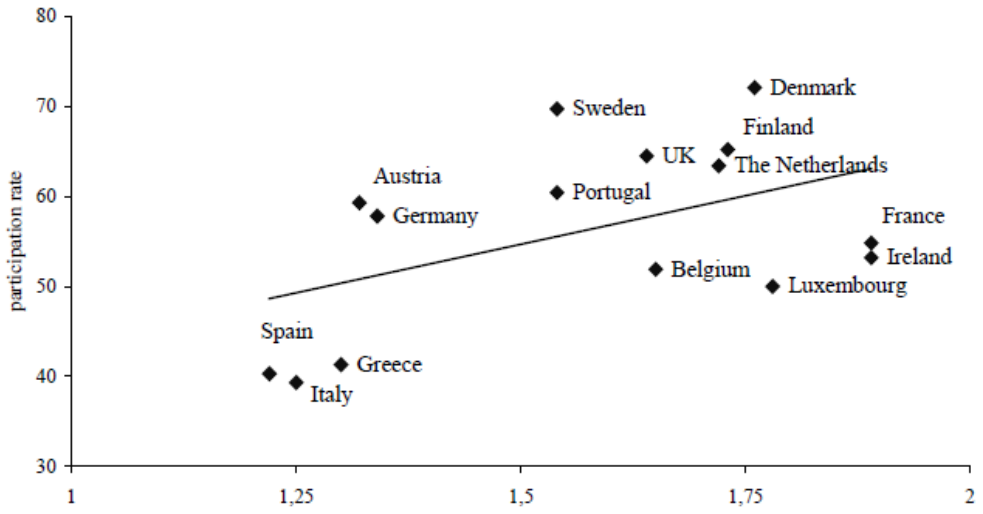


Figure 1.7: Women's participation and fertility in Europe (Source: Boeri T., Del Boca D., Pissarides C. 2005)

Especially in the past (during the 1970s and part of 1980s), we can find some possible explanations for the negative relationship between women labour market participation and fertility rate and these could be resumed in:

- The potential reduction in the sustainability of the pension system;
- Lower growth of total population;
- Lower growth of the working age population;
- Lower savings;
- Greater numbers of people with few immediate family ties, which will increase of the demand for formal provision of services.

Going more into details, two contrasting schools have emerged to explain this relationship: the New Home Economics model and the Easterlin model. Both approaches attempt to explain for a negative relationship between female employment and fertility.

The first one focuses the attention on the changes in the values of women time whereas Easterlin points out the changes on relative income due to the demographic cycle (the baby boom and bust).

In the New Home Economics, fertility decisions are based, given an income constraint, on individual preferences and children cost. These last include opportunity costs (from reduced labour supply), child-care cost, and time cost of educating a child.

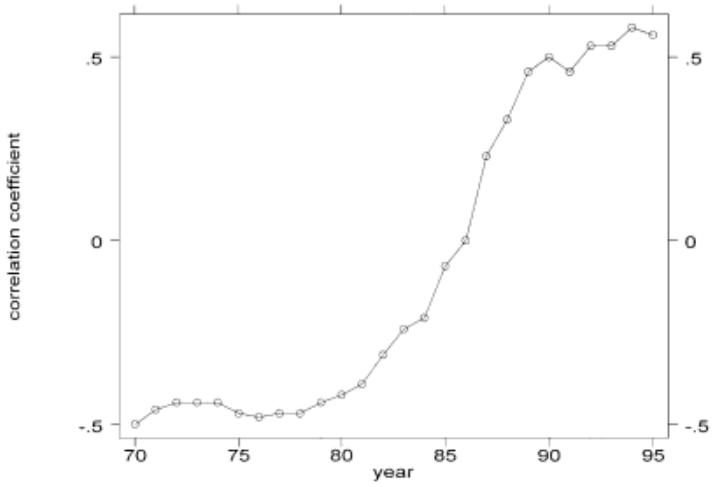


Figure 1.8: Cross-country correlation between total fertility rate and female participation (Source: Boeri T., Del Boca D., Pissarides C. 2005)

Instead, most recent studies capture the change in direction of the phenomenon signed in the late 1980s, showing an inverse relationship: the countries with lowest level of fertility are also characterized by low level of female employment rate (as confirmed by studies of Ahn N., Mira P. (2002), p. 670)

Possible explanations of this temporal change have been found in the changes in social norms towards working mothers and in the policies effect that tries to solve incompatibilities between childrearing and female employment: resuming them, we can affirm that the turn in the relationship has more often to be attributed to changes in economic constraints that women face in their participation choice rather than to changes in women's preferences. Social policy oriented to reduce the incompatibility between motherhood and career can be distinguished in policies that enhance employment flexibility (such as part-time jobs) and in policies that diminish potential cost of having children (subsidised child-care, parental leave, child benefits).

1.3 Features of the labour market

In order to illustrate the features of the economic constraints that women can face in her motherhood decision, we must start from a description of the whole labour force, focusing our attention on the dynamics that characterised the job world (especially in the last years).

1.3.1 The Italian context

Italy shares, with some other southern European countries, a series of negative records, such as the highest rate of long-term unemployment, the highest youth unemployment rate, the lowest participation rate of women and older workers, and, lastly, the lowest employment rate, which is very far from the target of 70% of the working age population that the European Union has set for 2010.

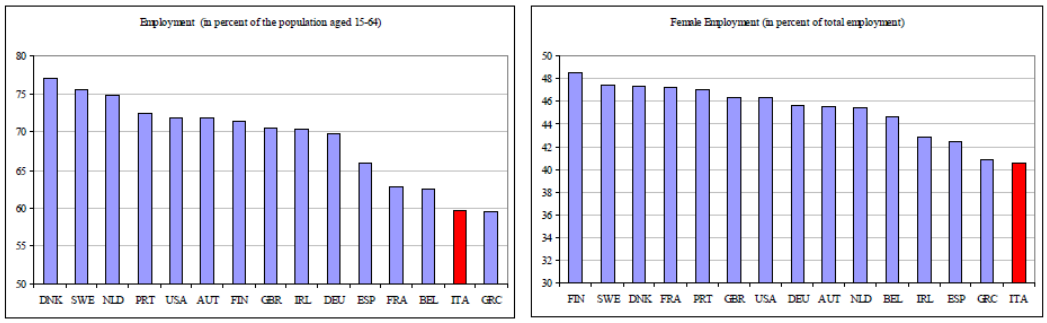


Figure 1.9: Italy's labour market outcome in cross-country comparison 2007 (Source OECD)

In order to going deeper into the explanations of this features we can use a standard way of assessing the functioning of a labour market such as looking at few indicators that are intended to capture the efficiency in using and allocating the available human resources. The usual indicators are the unemployment rate and the employment rate (the proportion of employed people over the working population).

Referring to these indicators, although the lower position of Italy in the European context, analysing the national level, we can underline a positive trend: employment

and labour force participation rates have increased, the unemployment rate dropped to around 6 per cent in 2007, down from a peak of over 12 per cent in the mid-1990s.

On the right hand side of Figure 1.10, in correspondence of an inverse relationship with the unemployment rate, we can observe the temporal path of the employment and labour force participation that shows a similar trend with the lowest peak around 1995, from which a positive path starts toward the highest value reached around 2007. In those countries where the unemployment rate is high, young couples tend to postpone household formation waiting to be well established in their jobs before a possible creation of their family. In this context, the low level of confidence about the future employment perspective is an important determinant of the low level of fertility. On one hand, women tend to participate more in the labour market to protect household income from negative shocks to the partner's wage; on the other, they do not leave their work position during childbearing years to protect their own labour market prospects (Bettio and Villa 1998).

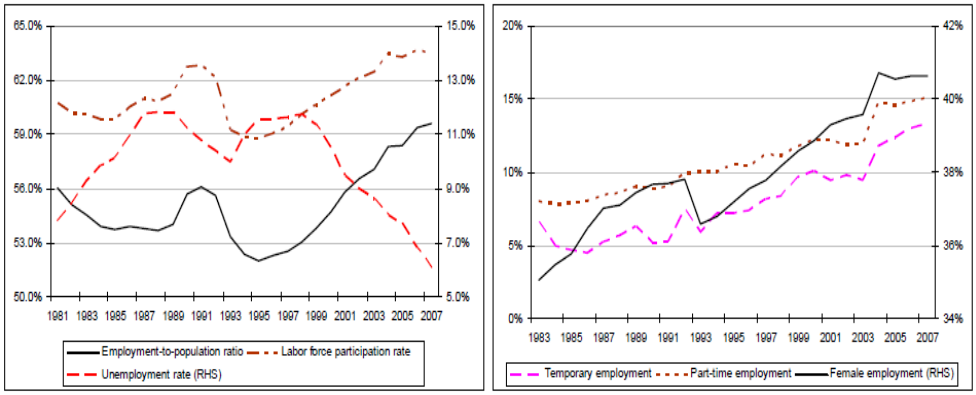


Figure 1.10: Recent labour market trends in Italy (source: OECD)

On the left hand side, instead, is presented a partition of the labour supply into temporary, part-time and female employment: the most dramatic increase is registered on the female side (from less than 35% up to 41% of participation rate).

The high level of unemployment (shown above), undeclared work on one side, and the low participation rate of specific segments of the population on the other (such as the female rate demonstrated in the previous part of our dissertation), make the aggregate distribution between work and not work difficult to sustain in the long run,

and in the specific case of Italy we must also observe that the population is aging more quickly than in other parts of Europe (as shown in Figure 1.11).

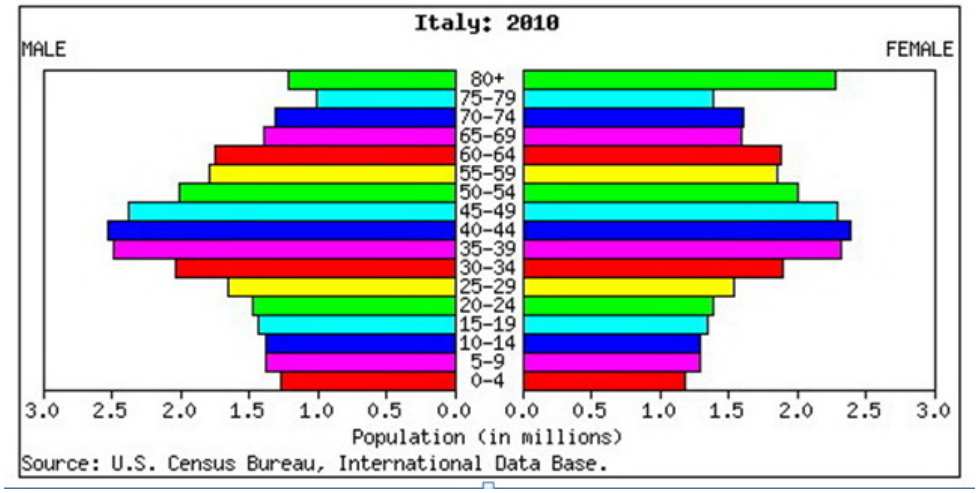


Figure 1.11: Italy Population Pyramid for 2010 (predicted age and sex distribution)

Two other important features characterize the Italian labour market: the first is the spread of undeclared work in the underground economy; the second is the regional disparities of the general conditions of the labour market. The search for an explanation of this poor performance leads to the institutional set-ups of labour and product markets.

1.3.2 The institutional context

Making a sort of historical review across the labour force legislation, we can refer first of all to the Treu Law (Law 197/1997), the first legislative measure aimed at increasing the employment rate particularly in the South, mainly by introducing temporal contract and providing incentives for part-time work.

Another contribution (Law 469/1997) based on the privatization and decentralization removed the principle of the public monopoly.

Effort in increasing the labour market flexibility can be additionally individuated in the Biagi reform (Law 30/2003): it deregulated the use of atypical work forms, such as

temporary agency work and part-time one, introducing also new forms as on-call jobs and occasional work.

Although these efforts in improvement, still today we can individuate in the Italian context some institutional factors that negatively affect the functioning of the labour market: we can cite union power, the features of the collective bargaining system, the tax benefit system, active labour market policies, employment protection legislation, unemployment insurance and regulations of the product markets.

Bargaining structure and Union Power. Concerning to the first, the main goal should be the internalization of the externalities: higher wages for one category of workers may produce negative effects for other groups. Wage decisions under uncoordinated collective bargaining will not take these negative externalities into account, but under co-ordination they can be internalised. Co-ordination works toward real wage restraint. As a consequence, employment is higher under co-ordinated than under uncoordinated bargaining. When collective bargaining takes place at the national level it tends to be co-ordinated. One form of co-ordination consists of the so-called "Social Pacts", which are agreements, establishing norms of moderate wage policy, inspired by the criteria of Maastricht aimed at making the country fit for the single currency target. One important effect of the Pact signed in Italy in 1993 (Cost of Labour Agreement) was an increased co-operation in the fight against inflation and public deficit.

Considering the main topic contained into this document, we can resume its structure in two-tier one:

1. Collective bargaining at the national sector level to determine the general conditions of the employment and the basic wage guarantees (*minimi tabellari*);
2. Bargaining at regional or firm level that is optional and it has to respect the previous category.

In Italy the first point is particularly relevant such that about 60% of Italian workers are covered by collective bargaining agreement on a higher level with respect to the European context.

In the bargaining procedure, the three major national unions (CGIL, CISL, UIL) have a fundamental role becoming a source for a strong dividing factor, since they have different ideological roots and this diversity sometimes emerges.

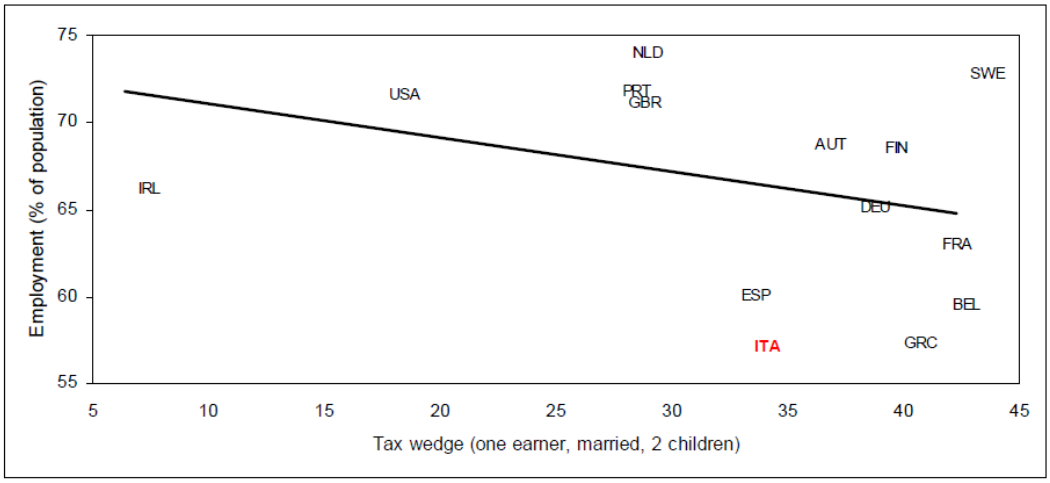


Figure 1.12: Employment versus Labour Market Regulation, 2003 (Source: OECD)

Tax Wedge. A second institutional factor (that the above scatter plot does not individuate such as fundamental in the Italian panorama), which affects the functioning of the labour market, is the so-called tax wedge (defined as the deviation from equilibrium price/quantity as a result of a taxation, which results in consumers paying more, and suppliers receiving less). Taxes on labour, such as social security contributions and taxes on personal income, tend to discourage the labour supply, while, on the demand side, increase labour costs and depress the labour demand. The combination of minimum wages and payroll taxes may be a cause of wage rigidity and higher levels of unemployment.

System of income support in favour of the unemployed. In Italy, the system is complex and uneven. While ordinary benefits are initially relative high (replacement rate of 60%), they drop to zero only after eight months. By contrast, Wage Supplementation Funds (*Cassa integrazione*) are substantially more generous, both in terms of level and duration, but are limited to workers on certain conditions (firm size, work area, number of employees). The lack of well-developed social safety hinders an efficient worker reallocation.

Another way to prevent people from staying unemployed for long is to adopt the so-called "Active Labour Market Policies" (ALMP). These policies include measures such as: public employment service, public training programs, youth measures, subsidized employment, and measures for disabled people and other disadvantaged workers. Job creation in the public sector and subsidies to private-sector employment are not very effective, unless they are small in scale and well targeted to the specific needs of both job-seekers and local employers.

The amount of resources spent on ALMP in Italy is not low, when compared with other countries, but there are the qualitative aspects of the policies that are still lacking. The Public Employment Service has been recently reformed and the running of the system has been decentralized from central to local government. But they are still badly organized and the results are very poor: the "penetration rate" of the PES is roughly 4%, which is extremely low if compared to the corresponding rate of other countries (Ministry of Labour Monitoring, 2002).

The employment protection legislation (EPL). Although it appears relative low with respect to the OECD indicators, market participants recognized permanent employment as fundamentally protected. However, the increase in atypical work augments employment risk for a greater fraction the labour force.

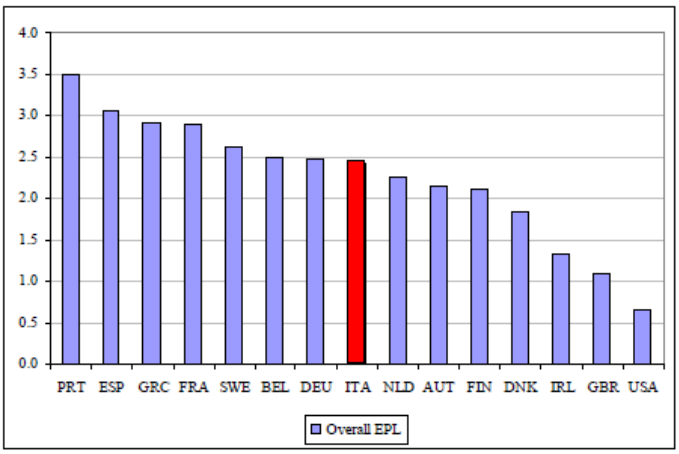


Figure 1.13: Employment Protection Legislation, 2003 (Source: OECD)

As the Figure 1.13 shows, the EPL level in Italy, in comparison with the other European countries is relatively satisfying, attesting itself in a medium level in the whole

panorama. But if we refer to the regression between employment and EPL the Italian situation performs a lower position than in the previous case.

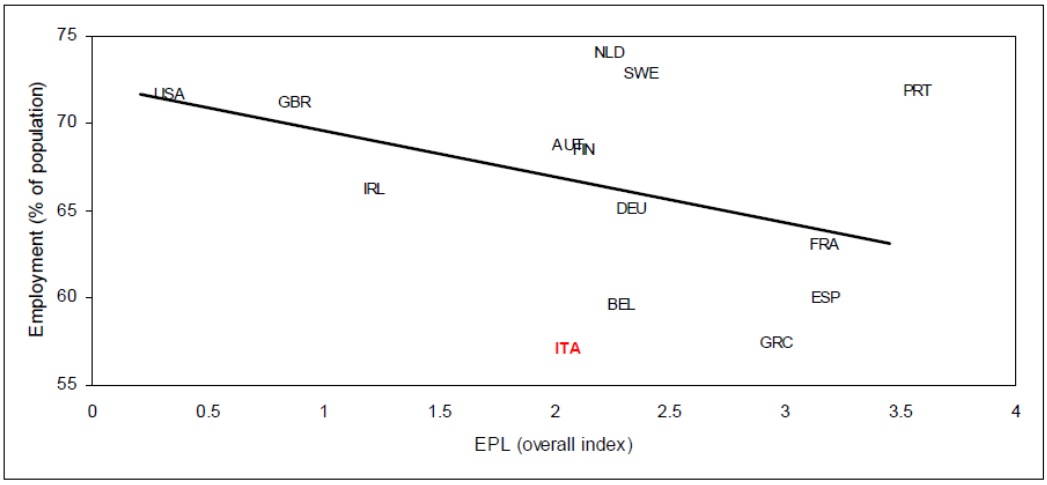


Figure 1.14: Employment versus Labour Market Regulation, 2003 (Source: OECD)

Regulation. The regulations of the labour market have an important impact on the participation rate especially in Southern European where markets are still highly regulated (particularly regarding hiring and firing of workers): this higher regulation is largely responsible for the high unemployment rate of women and youth.

In Italy this aspect is particularly relevant since it is ranked among the countries in the EU with the most regulated product markets, such as shown by Figure 1.15.

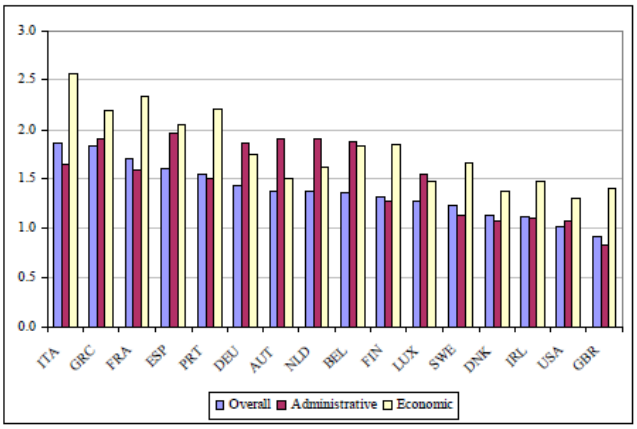


Figure 1.15: Product Market Regulation, 2003 (Source: OECD)

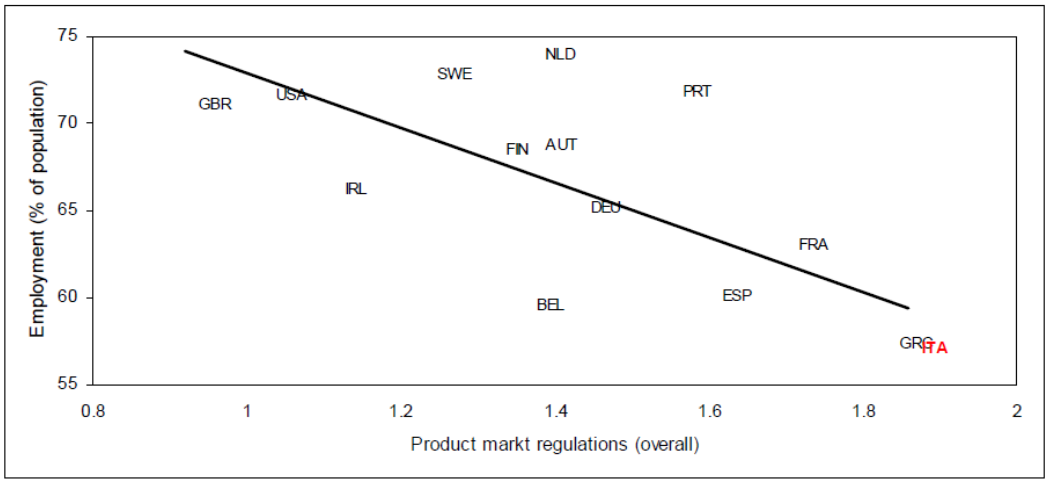


Figure 1.16: Employment versus Labour Market Regulation, 2003 (Source: OECD)

A key channel for the relationship between employment and market structure is the fact that in a monopolistic market, firms set prices at a mark-up over marginal cost, thus reducing the equilibrium quantity of output. Then increasing competition tends to result in a lower equilibrium price, higher output and, all else equal, higher employment.

1.4 Family Friendly Policies

A recent study has revealed that the Italian Firms show very low level of innovation with respect to the other countries' ones, referring to the family-friendly policies supply.

We can create, with Table 1.1, a sort of summary of the measures, based on the working features (left-upper side), on the leaves concessions (right-upper side), on the childcare provision (left-lower side) and on the Sustain measures (right-lower side).

We will proceed with a more detailed discussion only referring to some of these sequent topics.

Flexible office hours **Part-time** Flexitime Job-sharing Work at home Hours Bank Short-term Contract	Leaves **Parental Leave** Maternity Leave Paternity Leave Adoption Leave Career's Interruptions
Childcare Services Business Nurseries Agreements with local services Financial Support	Sustain Measures Worker Assistance Labour-Family Consultant Information supply Survey on employees' needs **Child Benefits**

Table 1.1: Family friendly policies (Source: Saraceno, 2001)

1.5 Part-time

For job supply, part-time can represent a flexible instrument to augment the presence in the job market, allowing maintaining a professional link during transitional life periods (job and formation, job and family, job and retirement) reducing the inactive amount of people.

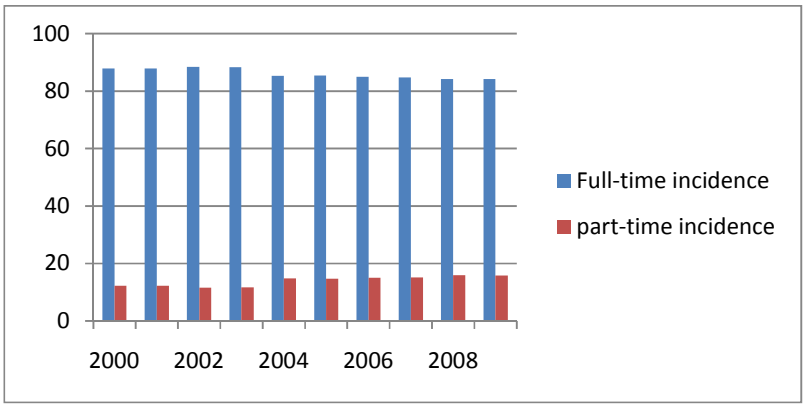
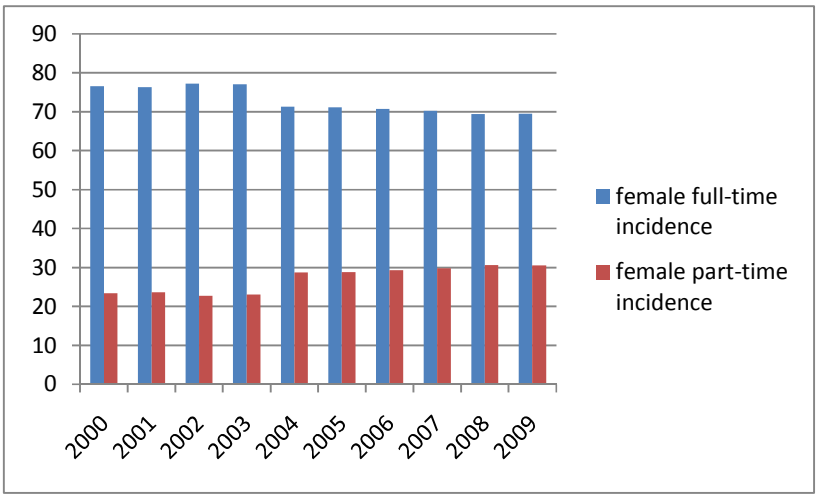


Figure 1.17: Part-time and Full-time incidence in Italy (Source: OECD)

Referring to the Italian context, the part-time job has particular features:

- It is growing as flexible instrument, particularly in service provision;
- It pertains to the atypical job forms growth trend;
- It is a typical female phenomenon more with respect to the other countries (as shown from the comparison between the two plots of Figure 1.18).



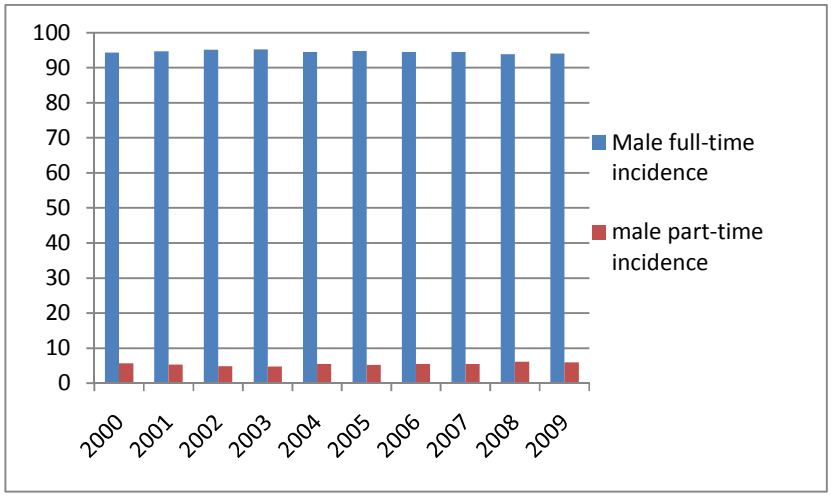


Figure 1.18: Female and Male full-time and part-time incidence in Italy (Source: OECD)

- It is spread in less qualified occupations;
- There exist a lower probability for a part-time work for divorced, widow, single women;
- The family dimensions are positive related with the probability of the part-time use (increasing dimensions, higher use of part-time job);
- The mean amount of worked hours is over 23 per week.

Once made a distinction between voluntary and involuntary part-time supply (the first one includes all the individual that choose part-time for personal reasons such as conciliation between work and formation; the second one, instead, can be considered as second best choice of the subjects who have not other possibilities of full time job. This last could also be interpreted as a forced work supply.

We can summarize the different part-time contracts in three categories.

The first is the horizontal part-time consisting in an activity with a daily reduced office hours (such as 4 hours instead of 8); the second is the vertical one in which the employee works only in pre determined days (this category includes also cyclical labour); the third is, instead, a mixture of the previous ones.

Additionally, we can observe that the part-time incidence changes a lot subject to the job definition adopted:

- On the basis of worked hours, we define a part-time worker who usually works less than 35 hours per week;
- On the basis of the normal office hours, we consider a part-time worker who has a normal office hours inferior to a full time one with similar job skills (definition usually adopted by ILO);
- On the basis of the interviewer auto declaration.

1.5.1 Juridical context in Italy

The first juridical contribute for part-time legislation can be individuated in the 1994 (Law 19/12/1984, n. 863 *"Misure urgenti a sostegno ed incremento dei livelli occupazionali"*), where it is recognised the possibility to offer reduced work hours to a particular workers categories such as students (to create incentive for formation).

Furthers improvements are contained in the legislative decrees n° 61/2000 (*"Attuazione della direttiva 97/81/CE relativa all'accordo quadro sul lavoro a tempo parziale concluso dall'UNICE, dal CEEP e dalla CES")*, n. 100/2001, subsequently modified with the art. 46 of the l.d. n. 276/03 (in order to increase the advantages in its use, augmenting its flexibility). However, the most significant provision in the Italian panorama is the Law 53/2000 (*"Disposizioni per il sostegno della maternità e della paternità, per il diritto alla cura e alla formazione e per il coordinamento dei tempi delle città"),* that provides specific dispositions on timetable flexibility.

Additionally, the National Plan for employment 2001 and 2002 (related to the European recommendations of augmenting the part-time presence on the Italian labour panorama) talks about the goal of increasing the number of part-time jobs as an important strategy of employment growth, especially considering the female side of the supply. In this perspective we can refer to the reduction of the taxes related to the part-time job contract provided by DM 12/04/2000.

1.5.2 Part-time: an economic perspective

The possibility of combining work and childrearing depends strongly on the occupational structure with, for instance, the presence of the part-time conditions. However, the development of this opportunity has not increased homogenously in all advanced countries: while in the northern European countries a relevant part of women is employed part-time; in the southern countries, the tertiary sector is less developed and part-time availability is very limited. For these reasons, in those realities, women are forced to choose between not working or working full time (which is not compatible with a large number of children).

Greater opportunity for part-time availability also reduces the cost of having a children and it has a positive impact on fertility rate. However, part-time work may have also negative effects on wages and careers perspective particularly by considering the fact that this type of job tends to be more frequent in low-qualified occupations. So, even if a woman, after the child birth, carries on to be employed, she could fall in a occupation inferior to which she had before in term of quality, payment and responsibility (Gutierrez-Domenec M. 2002).

A comparison across European countries shows that only in few countries, the probability of changing from full time activity to part-time one, after childbirth, is higher than the probability of living at all the labour market.

Especially in the Southern European countries, public childcare (the most spread one) is also characterized by extreme rigidity in the number of weekly hours available. This makes the service compatible with part-time work but not with full-time activities. Given that part-time work is very limited in Southern Europe, married women are forced to choose between no work or full-time work, neither of which is necessarily their preferred option (evidence coming also from Figure 1.19 that confirms this theory especially for Spain and Portugal). Therefore, married women who choose to work tend to have full-time work commitments, which are not compatible with having a large number of children.

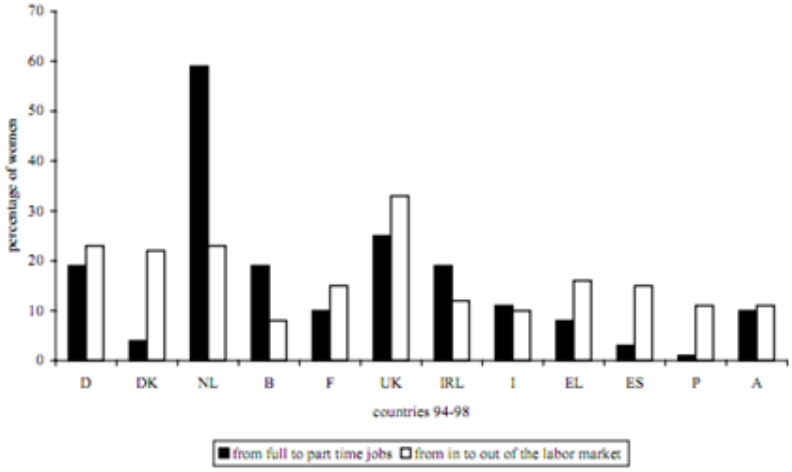


Figure 1.19: Transition in Europe around first childbirth

1.6 Childcare

The presence of children affects mothers' preferences with respect to non-market time versus market time. Social policies directed at reducing the costs that children incur by increasing the availability, quality, and affordability of childcare may affect fertility and participation rates. Studies on temporal patterns have shown that the increased availability of childcare is one possible explanation for the change in fertility over time and for the observed changes in the relationship between women's participation and fertility (from Ahn and Mira 2001).

Additionally, "according to Becker's (1981) theory of household production, families combine time and other resources to produce commodities in a way that maximizes their satisfaction or utility subject to time and budget constraints. Family members compare the utilities of various allocations of time spent in employment and home production on the basis of the relative satisfaction each combination produces in addition to basic household goods and services".

However, yearly childhood education and care differ substantially across countries. On one hand, there are different opinions about the optimal age in which children socialisation should start. Some countries sustain the importance of the childcare availability from the end of maternity leave onward; others, instead, are in favour of postponing the beginning of the social care when children are three years old.

On the other hand, countries are different also in the consideration of the responsibility for the childcare between the domestic, public and private sphere.

For some of them "having children" is considered as a private choice and so parents have to sustain privately the children cost, whereas government support is targeted only to poor families; in many other ones, it is considered a sort of right that the institutions have to guarantee, such as part of public field and in this case the state has to help parents in the maintenance of their standard livings also after the childbirth independently of family income.

Referring to these different views, governments can act on three levels to provide care for children:

- Direct supply and organisation of public childcare;

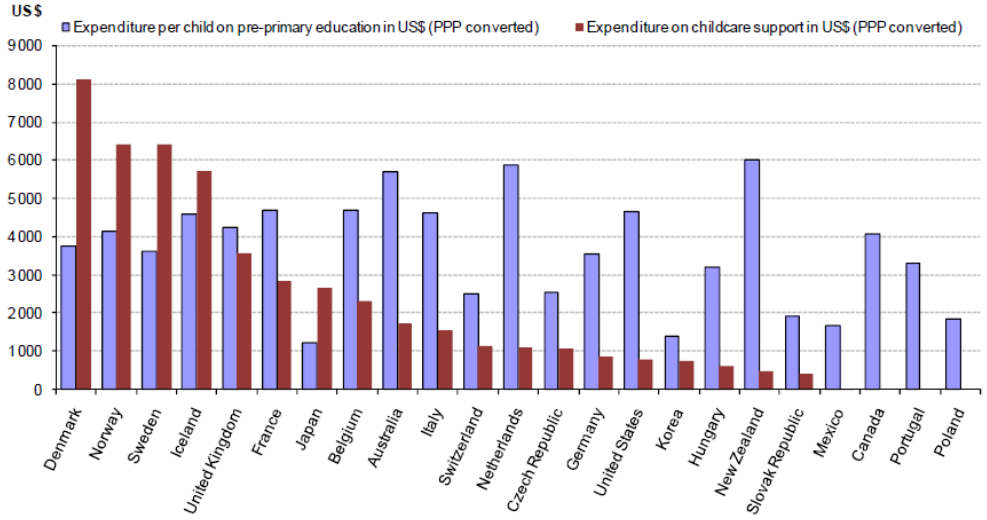


Figure 1.20: Expenditure per child on childcare and pre-primary education on US$ (PPP converted), 2005 (Source: OECD)

- Replacement income and/or job protection for parents who temporarily leave their jobs to take care of their children (maternity, paternity leave around birth and parental leave later on);
- Direct financial support to families to help them in purchasing care on the market (tax benefits).

Making a further physical distinction in the provision of childcare services we can split in internal and external one. Related to the last one, countries implement two-fold system including the collective childcare systems (public or private facilities with skilled staff looking after children during the day) and subsidised professional child-minders receiving children in their own house.

Barcelona European Council of March 2002 reports "Member States should remove disincentives to female labour force participation and strive, taking into account the demand for childcare facilities and in line with national patterns of provision, to provide childcare by 2010 to at least 90% of children between 3 years old and the mandatory school age and at least 33% of children under 3 years of age" in order to remove the discrimination between women and men in the labour participation.

In order to reach the goal established by Barcelona Council we have, first of all, focus our attention on the criteria able to group into two main categories the public childcare system. These categories are: 1) the coverage rate of childcare system

measured by three indicators (proportion of children covered, public share in the costs, opening hours of care facilities); 2) the child/staff ratio (number of children per full-time equivalent qualified carer) and the public spending on education for children aged 3-5.

The first one measures the proportion of children of a particular age group who received some form of public childcare, in order to look at the availability and not a statistical measure, we have to consider the proportion of available places rather than the number of enrolled children. A further element to describe the overall coverage rate is the daily coverage, referring to the spread of opening hours of formal childcare arrangements (probably, the larger the opening hour, the greater the adaptation to the parental working hours). Finally, we can focus on the support of the cost for the childcare that could be provided through public funds or parent fees.

Going more into details we can analyse the relationship among the above categories: "(i) The higher the coverage rate, the longer the opening hours of care facilities and the larger the public share of the cost, the greater the proportion of children in public full-time free care, therefore the easier it is for parents to engage in paid work, even at atypical hours; (ii) the smaller the number of children per trained carer, the higher the level of professionalism of a country's public childcare system and the better its quality; and (iii) the higher the level of public spending per child in education, the better system's infrastructure, the more attractive employment in this branch, and the higher the quality of child development." (from De Henau J., Meulders D., O'Dorchai S., p.30, 2007).

In order to make an overview on the cross-countries childcare provision, we have firstly to distinguish between two different age categories: the *infants* one (children between 0 and 3 years old) and *pre-school age* one (between 3 and 5 years).

Infants. Related to this subset we can map the countries into 3 categories:

- Anglo-Saxon countries where the childcare provision is entirely provided by private efforts at local level;
- Mediterranean countries in which the system is mainly supported by families;

- Luxembourg, Austria, the Netherlands and Germany where the responsibility for the socialisation of children is in the mother's hands, requiring their full-time commitments to childrearing.

In particular we can look at the generosity of the Nordic countries, such as Finland and Sweden, in which each child has the legal right of having a place in collective childcare from his/her first year of age onwards, due to the high individual consideration and to the relevance of the equality between men and women in this typology of society.

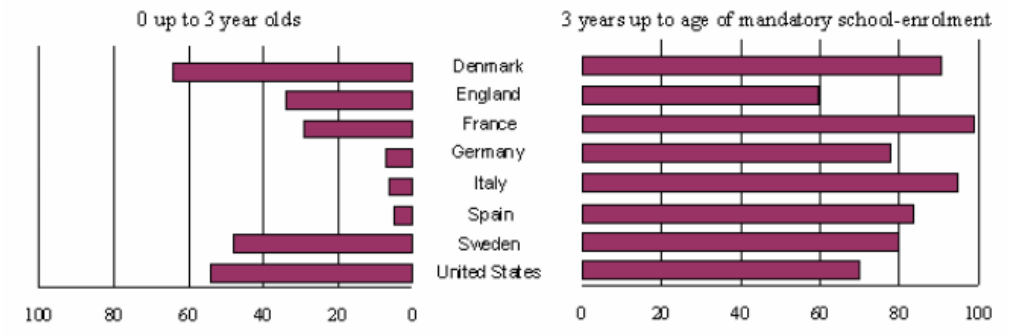


Figure 1.21: Proportion of children using childcare, 2001 (Source: OECD)

As the left part of Figure 1.21 shows, the supply of child care varies across countries considerably.

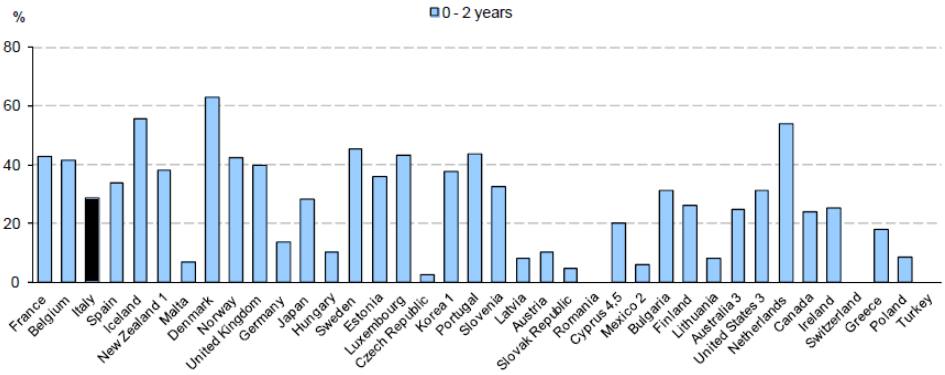


Figure 1.22: Average enrolment rate of children not yet three years of age in formal childcare, 2006 (Source: OECD)

Pre-school age. In contrast with the previous category, for this age group education facilities are more homogenously distributed, around more than 75% coverage in many countries (even higher if private provision is taken into account).

Generally three groups can be distinguished: the first one includes Belgium, Denmark, France and Italy (100% of children covered); the second one contains Luxembourg, Germany, Portugal, Sweden, Austria (70-79%); in the last one with the lowest coverage rate are grouped the Netherlands, Greece and Ireland.

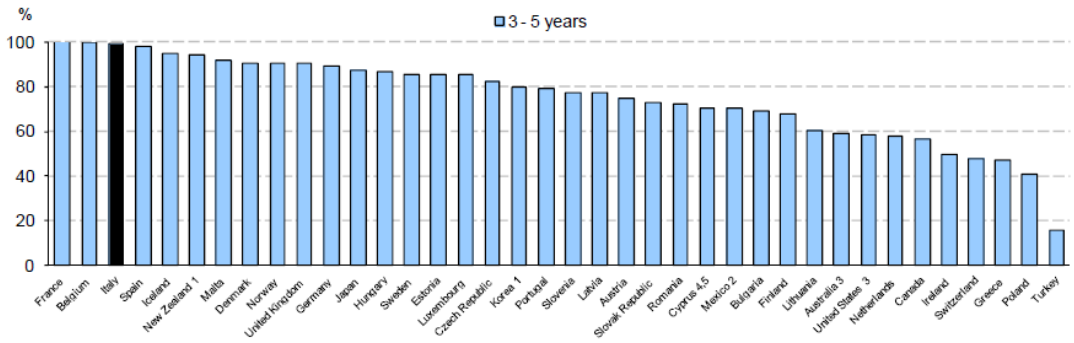


Figure 1.23: *Average enrolment rate of children aged three to five years of age in pre-school educational programs, 2006 (Source: OECD)*

Another important issue concerns the childcare service quality, which shows a positive correlation with the mother's job opportunities (the higher is the quality the weaker the preference of staying at home rather working), particularly true for families where only one child is present. Generally, in countries where childcare is provided mostly publically, the quality is higher and more homogenous; whereas the problem is more relevant in countries where childcare services are mostly privatively provided because they are usually less subject to monitoring activities.

There are several objective aspects of childcare environment that are often regulated by government: the number of children cared for in a group and by each care giver, care giver formal education and his specialized training in child development and aspects of the facilities that houses the child care program, such as amount of floor space per child.

Definition and Measurement of Quality in Child Care Programs			
What Was Measured and How	Areas of Comparison		
	Process Quality	**Structural Quality**	**Adult Work Environment Quality**
Aspects of Child Care Program	Interactions between child and caregiver, including caregiver sensitivity, harshness, detachment, and involvement with children Caregiver's attitudes toward children Presence of learning activities Health and safety aspects of the child care environment Presence of appropriate furnishings, equipment, and curricular materials	Group size Adult-child ratio Caregiver's previous experience in caring for children Caregiver's formal education Caregiver's specialized training in child care	Child care director's and caregiver's salary and benefits Annual turnover rates of caregivers and directors Caregiver's work satisfaction Caregiver's work commitment Caregiver's perception of job stress
Techniques Used to Measure Quality	Observations of children, caregivers, and child care environment	Observation Questionnaires Interviews Review of personnel records	Interviews with or questionnaires to child care program directors or teachers

Table 1.2: (Source: Helbur S., Howes C.)

Additionally, quality is related with costs: the ratio of specified personnel to the number of children and higher training levels are positively related to the quality care, but on the other side, high-quality cares costs more.

The cost of childcare can be viewed from the perspective of the provider, the parent and society. From the societal one, it could be important the value estimation of all resources used for the childcare provision. The last one is provided in a sort of mixed market of for-profit, non-profit and publicly operating centres and licensed and unlicensed child care homes.

1.6.1 Childcare system in Italy

In the Italian context, we can find three main patterns: according to the ISB data, in 2002 50% of Italian mothers took care of their children; slightly more than 30% used grandparents or other relatives, taking on (informal) childcare; only 20% used formal care. In 2005 the percentage of parental childcare fell to 46%, whereas both formal and informal childcare increased (33% and 21% respectively).

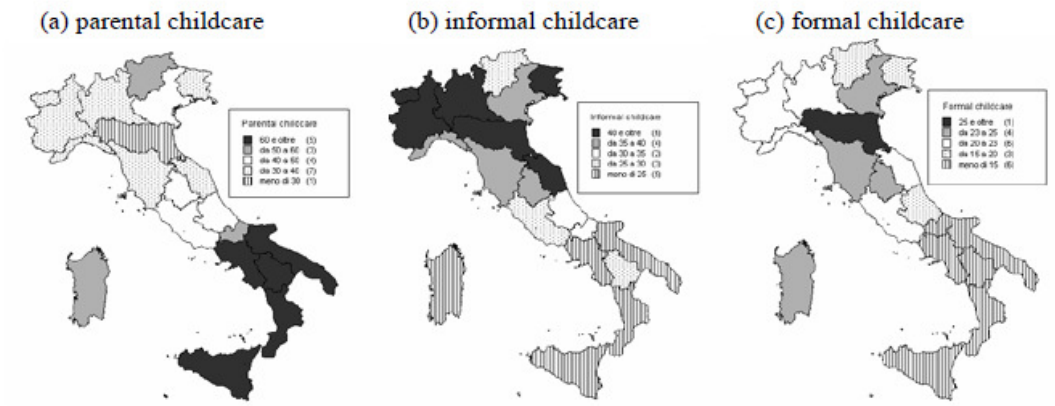


Figure 1.24: Percentage of mothers by region of residence and childcare arrangement, 2002 (Source: ISB data)

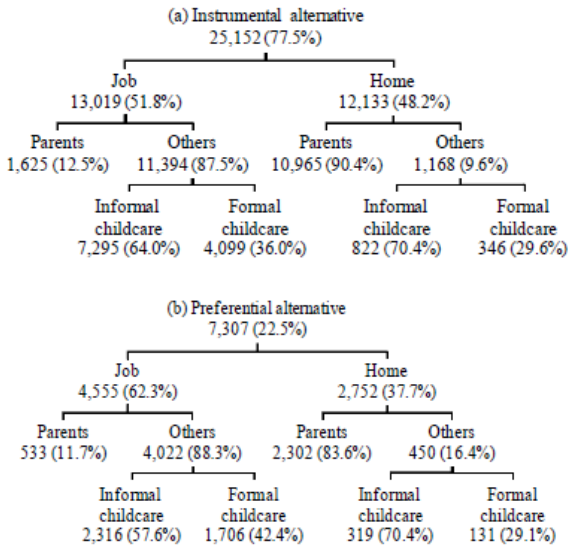


Figure 1.25: Mothers interviewed by (a) instrumental or (b) preferential attitude toward employment, occupational status, work choice, and childcare arrangement. Absolute values and percentages, 2002 (Source: ISB data)

1.6.2 Formal childcare

In Italy, as in other European countries, public childcare is the most spread type of formal childcare and it is characterized by high quality standards. However, the availability remains limited and highly regulated in terms of hours and access rate; additionally, a private childcare system has not yet developed in order to compensate for the limitation of the public one. The features of childcare vary significantly with respect to the children age and region. While for children greater than 3 years public childcare is provided both by state and municipalities, for whose inferior of 3 years, it is own provided by local municipalities. The availability of public care is high for the infant's category where it is reached the same coverage proportion as the in the other European countries. Focusing the attention on the distributional issue among regions, we underline homogeneity in the childcare availability for the pre-school category.

Region	Public availability (%)	Private availability (%)*
Emilia Romagna	17.4	0.88
Valle d'Aosta and Piemonte	9.72	1.06
Umbria	10.6	0.97
Marche	10.7	0.65
Toscana	9.7	1.85
Lombardia	8.9	0.81
Liguria	9.3	0.27
Lazio	7.5	0.73
Friuli	6.1	1.84
Trentino	6.8	0.76
Italy	**7.0**	**0.91**
Veneto	5.5	1.73
Sardegna	5.7	0.73
Basilicata	4.4	0.79
Sicilia	4.7	n.a.
Abruzzo	3.8	0.23
Molise	2.5	0.38
Puglia	2.1	0.64
Campania	1.0	1.24
Calabria	1.1	0.82

Table 1.3: Public and private childcare availability by Italian regions, 2002

(Source: Fondazione degli innocenti. I servizi educativi per la prima infanzia)

As shown by the Table 1.3, private childcare is not widespread as the public one. Regulation seems to have affected the private market, limiting both its supply and development. Both public and private are less available in the South than in the North, showing that public and private supplies are complementary rather than substitute.

The actual availability of places seems not to satisfy households demand: the proportion of applications (as depicted by the Table 1.4) shows the potential demand for the public service. Among those eligible, only around 10 % really apply for it.

Region	Applications (%)	Children on the waiting list
Emilia Romagna	21.1	20.8
Piemonte-Valle d'Aosta	16.8	38.9
Umbria	14.2	29.8
Marche	13.7	33.1
Toscana	15.9	35.7
Lombardia	11.9	31.4
Liguria	20.6	56.7
Lazio	11.4	37.5
Friuli	9.4	39.8
Trentino	8.5	27.0
Italy	**9.9**	**32.7**
Veneto	8.3	41.7
Sardegna	7.6	36.0
Basilicata	5.0	27.2
Sicilia	5.9	29.6
Abruzzo-Molise	3.2	11.5
Puglia	2.5	29.0
Campania	1.6	40.7
Calabria	1.3	27.6

Table 1.4: Percentage of applications and children and the waiting list in the public childcare by Italian regions, 2001 (Source: ISTAT, annuario statistiche italiane)

When we consider the percentage of children in waiting list, we can see that 33% on average in Italy are in this condition.

Once having evaluated the service availability, we can look at its cost that varies by the child age: childcare costs for infants are higher than which for the pre-school in both public and private sector.

Generically, the Italian context is characterized by a very limited use of public childcare. This behaviour could have several explanations, such as the family preferences (values and gender roles), particularly spread in the Southern countries. According to this view, mothers are the best caregivers and, for this reason, parents rely on the assistance of parental care also if mothers are full time employed. However, parental preferences for childcare arrangements might change when children grow up.

Secondly, the problem is related to the existence of fixed costs (cost of transportation, clothing) that do not vary according to the service hours. Usually, this type of costs are

higher for younger children especially in areas where public childcare places are few causing higher travel costs, discouraging parents interested in using the service only for few hours.

Thirdly, also the rationing of childcare could be considered: parents who are willing to purchase public childcare may find a long waiting list access to which depends on their income, working status, family composition and children health.

	Children ≤3	Children >3
Public	12.01	69.0
Private	5.59	29.02
Informal	82.40	1.98

Table 1.5: Childcare use of working mothers for infants and pre-school age, 2005 (Source: Del Boca D., Locatelli M. , Vuri D.,)

1.6.3 Informal childcare

Informal care is generally defined as care arranged by the child's parents either in the child's home or elsewhere, provided by relatives, friends, neighbours, babysitters or nannies and it is generally unregulated.

Many families, indeed, may rely on the assistance of relatives who they know and trust, preferring an effort to maintain some stability for children who may suffer from their parents' absence because of their participation in the labour market.

However, in Meltzer's (1990) survey grandparents "were regarded as the most satisfactory carers' if the choice was between different relatives; grandparents were found to provide outings, opportunities for problem-solving activities, music and messy play more frequently than other relatives used as carers."

Grandparents could be considered the core component for the family support, taking in account an intergenerational exchange in which they constitute an important emotional and economic resource for parents and children. Even if the proportion of children living with grandparents remains relatively stable over time, the absolute number of grandparents looking after children increased a lot during 1990s. Once put aside the extreme case in which children live with their grandparents because of

serious juridical and health problem of parents, we focus our attention on a more common arrangement in which grandparents provide assistance to non-co resident kin.

Making a sort of review on the literature related to this topic, we can cite Guzman (2004) who reports that almost 50% of grandparents provide several types of childcare, underlining a correspondence between data coming from Europe and US.

Cherlin and Furstenberg (1986), instead, provide a classification of grandparents and their relationship with grandchildren, making a distinction among influential, supportive, passive, authority-oriented and detached clusters.

Vandell (2003) focused her attention on the intensity of care rather than on the relationship field, she makes a distinction between extended full-time (30 or more hours per week), extended part-time (less than 30 per week), sporadic and no-routine care received by grandchildren.

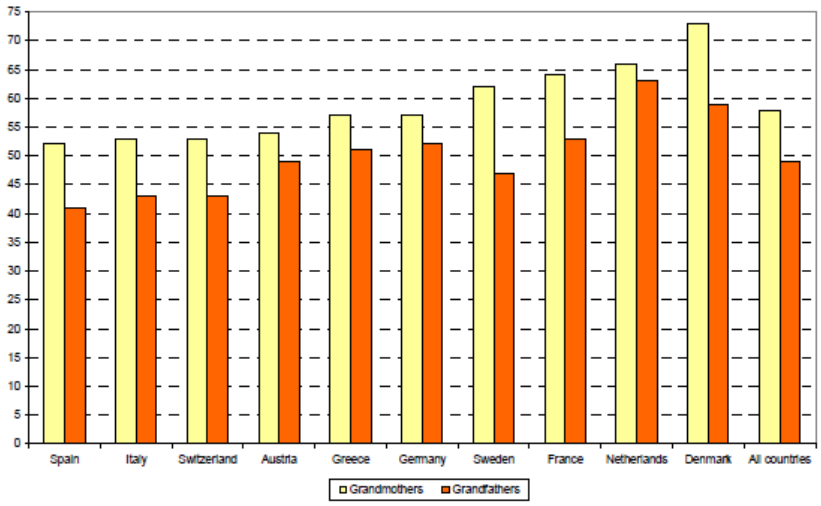


Figure 1.26: Grandmothers and grandfathers who provided any childcare over the past 12 months (in %; countries sorted in ascending order for grandmothers), 2004 (Source: SHARE)

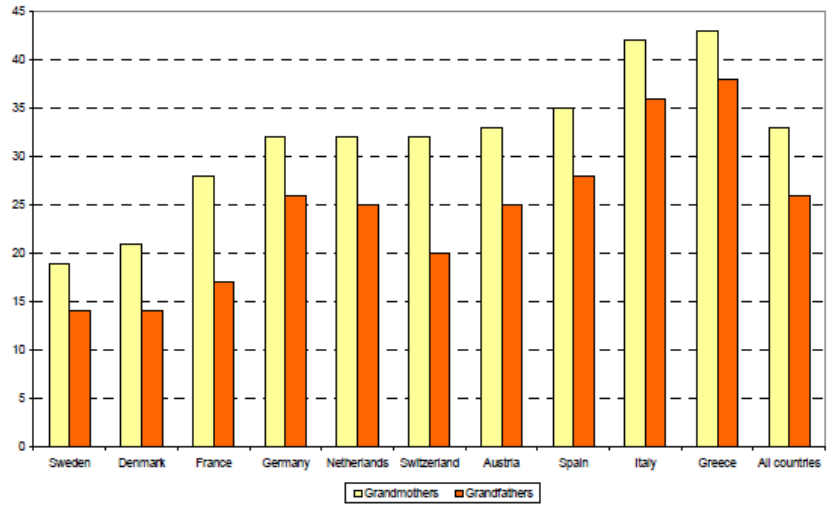


Figure 1.27: Grandmothers and grandfathers who provided childcare "almost weekly of more often" over the past 12 months (in %; countries sorted in ascending order for grandmothers), 2004 (Source: SHARE)

Jendrek (1993) considered the fact that the care for child is both labour intensive and time consuming, being a source for reduction in the time to pursue other activities especially if grandparents are still in the labour market.

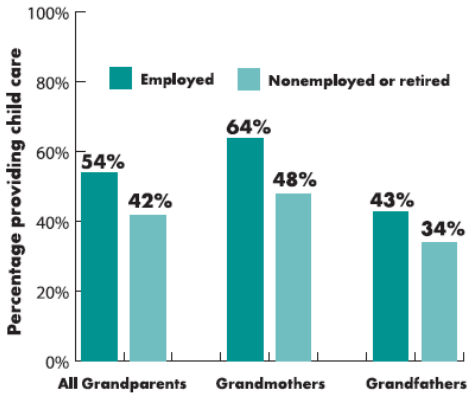


Figure 1.28: Percentage of grandparents providing childcare by employment status, 1993 (Source: NSFH)

She found that 80% of grandparents who cared for their grandchildren had to alter routines and plans in order to do this and 50% had less time for themselves and

friends. On the up side, 55% of grandparents reported that caring for their grandchildren gave them more purpose for living.

Looking at the demographic spread of the phenomenon, we can see that grandmothers are more likely to be engaged in childcare than grandfathers.

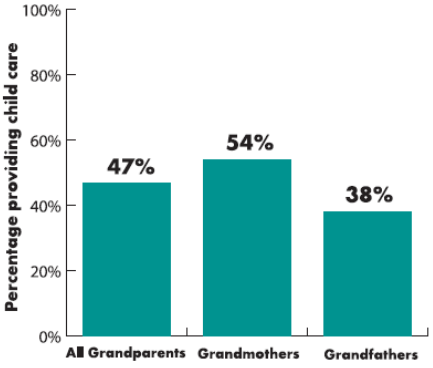


Figure 1.29: Percentage of grandparents providing childcare 1993 (Source: NSFH)

With regard to age, evidence from Britain suggests that the provision is attested among women around 50s and 60s.

Moreover, considering the US scenario, it's possible to divide the category in older grandparents, providing financial assistance and younger grandparents, tending to live closer to (due to the positive relationship between geographic proximity and grandparents' propensity to provide childcare) and having greater contacts with grandchildren.

Some studies found that around 60 per cent of adults between 30-50 years old (with grandparents still alive) live within 30 minutes journey from their mother's home. This is even more stressed in the case of younger and less educated grandparents or, alternatively, when parents are separated. With respect to the labour force participation, the employed grandparents childcare provision appears higher in percentage but lower in quality; whereas for the retired grandparents holds the contrary.

1.7 Child Benefits

We have to expect that any governmental measure with the purpose of reducing the costs of children should have a positive effect on the demand for children. First of all we have to make a distinction between measures aimed at reducing the direct costs of children (direct expenditures) and measures reducing the opportunity cost (foregone earnings). The relevance of these effects may depend on the work status of the beneficiary: cash benefits implement greater effects on unemployed women rather than on highly paid executives; on the other hand higher cash benefits may increase demand for children but also demand for higher quality.

There exist huge differences in means available to fund family support:

- Support through the tax system: granted through income taxation system in the form of tax allowances, tax credits or a system of tax shares such the French family ratio ("quotient familial");
- Direct support with a cash allowance granted to each child, sometimes means-tested.

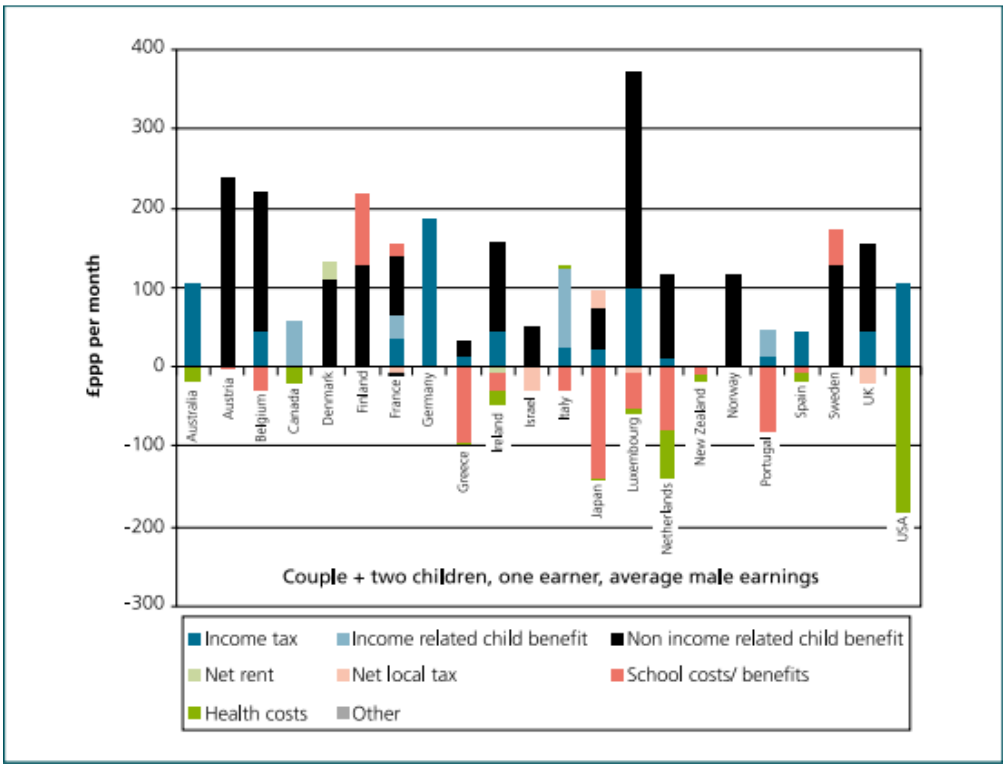


Figure 1.30: Structure of child benefit package, 2002 (Source: J. Bradshaw and N. Finch)

In all countries, except in Southern Europe (where this right is open only to salaried workers' children), cash benefits are usually granted to all families with children under a certain age, whatever their parents' or relatives' employment status.

The amount of cash benefits varies, depending on the age and the rank of children and on the type of family (lone parents, dual-earner, and one-earner couples). All European countries (Except the Southern) apply a system of flat-rate monthly payments made independently of parents' income. They show many particular features. First, they avoid to stigmata specific vulnerable groups, efficiently reaching all families concerned. Second, since benefits are granted on monthly basis, they are more easily perceived as a regular financial aid, whereas tax relief (collected with a year time lag) is usually seen more as a bonus *una tantum*. They, additionally, avoid also the so-called *wallet to purse* phenomenon (the fact that cash benefits are directly linked to the child and granted to the mothers increases the probability of their effective use).

Differently, in Italy, Spain and Portugal cash benefits are means-tested, varying with respect to families income levels: in these countries family policy relies on the idea of vertical redistribution with the aim of concentrating the most available means on the neediest. However, these countries remain at a lower level if we consider the final ranking because only low amounts are granted.

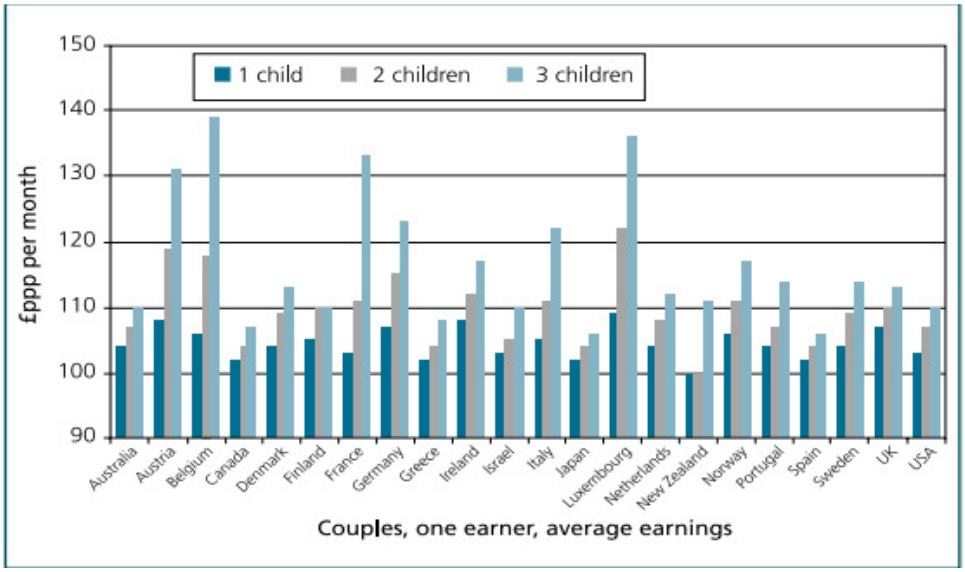


Figure1.31: Child benefit package by number of children, 2002,

(Source: J. Bradshaw and N. Finch)

Can be also useful underline the different effects of child benefits on women with different number of children: if the same benefits are paid for each child regardless of birth order, benefits can have increasing influence on the decision of having a great number of children since their cost will decrease at each additional child (economies of scale).

Before starting to analyse the cross-countries evidence between fertility and child benefits we have to focus our analysis on three important factors. First, child benefits may be greater for lower income households, and so fertility would increase in households where the average number of children is higher. The second aspect concerns the potential discouraging effect on mother work supply: a possible effect of such support, if it is perceived as being too generous, is the risk to quit the labour market. Thirdly, if the benefits are not issued for a specific purpose of purchasing market care, they can be used to pay other needs (food, clothes, etc.).

The cross-country comparison shows that the results also at European level vary widely. While cash-benefits do not affect fertility in Anglo-Saxon countries, they have a positive effect on the Northern one, in the Southern countries the effect is relevant only for the first child.

1.8 Parental leave

Parental leave is an employment-protected leave of absence for employed parents, which is often supplementary to specific maternity and paternity leave periods and usually, but not in all countries, follows the period of maternity leave. Entitlement to the parental leave period is individual, while entitlement to public income support is often family-based, so that in general only one parent claims such support at any one time.

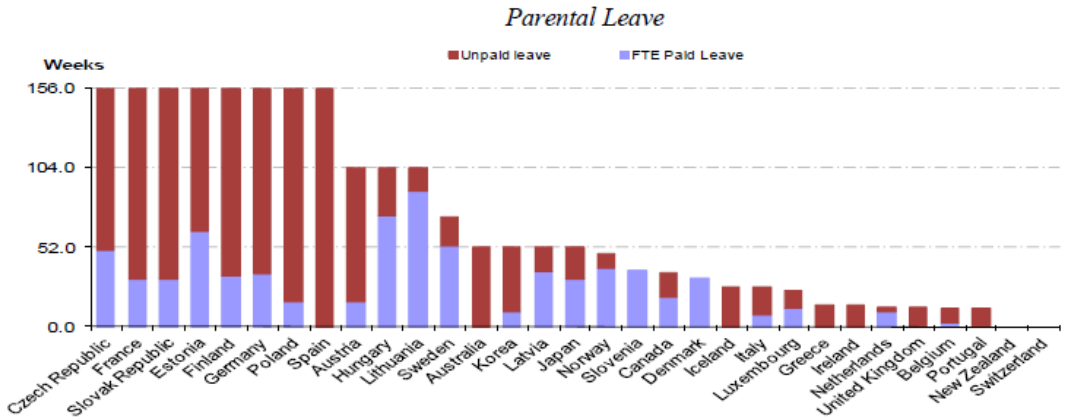


Figure 1.32: Child-related leave periods by duration of unpaid leave and the duration of the full-time equivalent of the leave period if paid at 100% of last earnings, 2006/2007 (Source: OECD)

The first two countries to introduce parental leave were Hungary in 1967 and Sweden in 1974. Most recently, the November 1995 Agreement on parental leave was signed between the trade unions and employers' organisations of the European Union that considers parental leave a key element for the work/life balance, and indeed, in 1996, it issued a Directive (96/34/EC "EC Parental leave directive"). This was the first time that the social partners had successfully availed themselves of the negotiating procedure provided for in the Social policy Agreement appended to the Treaty on European Union and thus bypassed the European Commission in initiating legislation. According to this procedure, a draft directive concerning a social policy matters on which agreement has previously been reached between the social partners at European Union level is placed directly before the Council of Ministers of the European Union for adoption. If adopted, the directive in point, takes immediate effect in all the

Member States without the Commission having to be informed formally. In this case, however, it was the Commission that had handed over the project to the social partners in the first place. Consequent to the fact that this event is a first in International Labour Law, the incorporation of the Directive's provisions into national legislations has a number of practical implications. The Directive sets standards that are mostly lower that those already in force in Member States; by imposing the member state to offer at least 3 months, after the child birth, of parental leave to all employees. This has to be added to a minimum of 14 weeks of maternity leave. The EC definition provides enough space for each state to implement its own rules in terms of leave duration, payment and flexibility.

The maximum is a leave of six months for mothers and six months for fathers. If the father takes three months' paternity leave the total parental leave can be extended to 11 months. Otherwise no more than 10 months are possible. The payment is thirty per cent of earnings when leave is taken for a child under three years. After that age, and up to the age of 8, parents are entitled to take unpaid leave. Only in the case of low earners state financial aid can be granted. Leave can be taken at any time until a child is eight years old. There are two options for taking this leave: a single leave period up to a maximum of six months; or shorter leave periods amounting to a maximum of six months. It is possible for each parent to take leave at the same time. A lone parent is entitled to ten months' leave. The transposition of the EU Directive 2006/54/CE, will also stipulate that leaves can be taken on an hourly basis. Unpaid leave can be taken without limit for a child under three years, while after that age there is a limit of five days per parent. The father is entitled to leave even if the mother is not, for example if she is a housewife. As the leave is per child, each parent is entitled to additional leave in the case of a multiple birth (e.g. the length is doubled for twins, tripled for triplets). Public sector employees receive 100 per cent of earnings during the first 30 days of leave. There is no childcare leave or provision for career breaks. The same regulations, as for parents having their own children, apply in the case of adoption.

In particular, in the 2007 the Italian Government introduced further improvements:

- Incentives for the creation of flexible working hours, linked to the need for conciliation and to favour an increase in female employment levels;

- Revision of the norm regarding parental leave, with particular reference to the extension of the period of leave and the increase in relative indemnity;
- Strengthening of interventions at various governmental levels in matters regarding services for children and elderly people which are not self-sufficient;
- Directing the intervention linked to the programming of the use of European Community Funds, giving priority to female employment.

By the legislative point of view, it is useful to analyse attractiveness of a country's leave system considering two indicators. The first one is the arithmetic average of three synthetic and scaled criteria: (i) the average of the scaled job-protected proportion of the leave, the scaled seniority-protected share and the scaled paid part; (ii) the average of the scaled degree of flexibility in the timing of take-up and of the scaled child age limit; and (iii) the scaled level of replacement income expressed as a percentage of average female earnings.

The second indicator, instead, is the arithmetic average of two indicators: (i) the reversed scaled total period of leave minus the share reserved for the father, and (ii) the scaled ratio of total average household earnings if the father takes the leave instead of the mother.

Paternity leave is an employment-protected leave of absence for employed fathers at the time of childbirth in which workers often continue to receive full wage payments. It is not stipulated by international convention and the periods considered are much shorter than for maternity leave. An index indicating the paternity leave is the scaled equivalent number of fully paid working days.

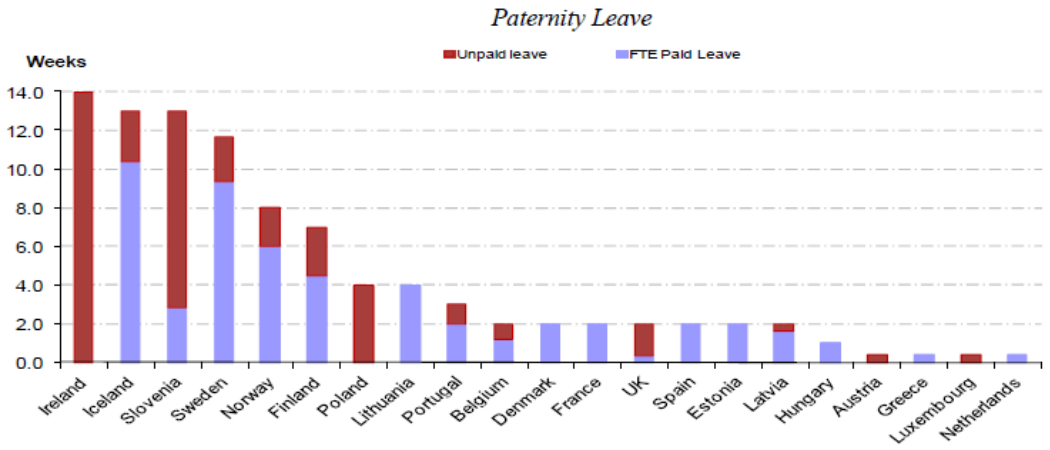


Figure 1.33: Child-related leave periods by duration of unpaid leave and the duration of the full-time equivalent of the leave period if paid at 100% of last earnings, 2006/2007 (Source: OECD)

Maternity leave consists in an employment-protected leave of absence for employed women at around the time of childbirth, or adoption in some countries. Almost all OECD countries have public income support payments that are tied to taking maternity leave. It can be indexed by evaluating the weighted average of the scaled number of fully working days (weight for two thirds) and the reversed scaled qualification period (weight for one third).

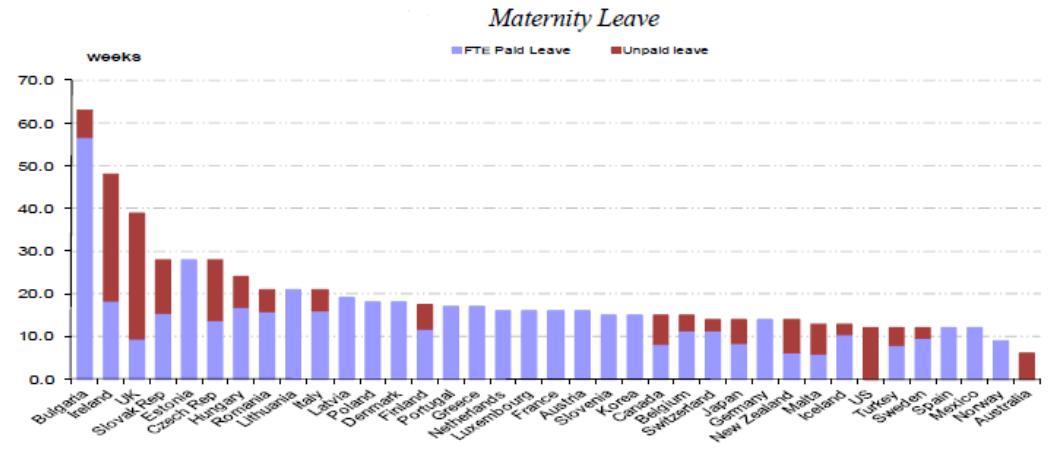


Figure 1.34: Child-related leave periods by duration of unpaid leave and the duration of the full-time equivalent of the leave period if paid at 100% of last earnings, 2006/2007 (Source: OECD)

Concerning the maternity leave, and in general the parental leave, we can say that it is an important element for helping women to reconcile household responsibilities with work activities and the total rate of employment due to the fact that more women enter in the labour market since they have the access to leave.

The expected effect of the duration of leave could be considered ambiguous: the longer women stay out of the market, the greater is the skill deterioration and the lower are the career opportunities, by showing a classical negative relationship between maternity leave and female employment. However, a longer leave ha to be also seen as a positive instrument allowing to mothers to spend more time with their children retaining, at the same time, job security. From these considerations, indeed, it is possible to conclude that the positive effect of maternity leave on fertility and female employment is strictly related to the length of the leave and to the benefits received by a mother during this period. At the European level, a comparison between the effect of compulsory and optional maternity leave regulations shows that the first one, if considered in a long length, has negative impact on the female employment, by increasing the hiring costs; in contrast, the length of the second one has positive effect on the general level of women employment.

Related to the first point, if we look at the labour demand side, it is clear that maternity leave could have negative impact on women's job opportunities, and in particular this could cause the so called *family gap*, a difference in wage between women with and without children. This is due to the fact that employers, in many cases, find risky or not convenient to hire young women who may be absent from work for long periods or better they prefer to give them jobs easily replaceable during the maternity leave.

Near the maternity leave, we have also to consider the possibility of paternity leave. By analysing the European scenario, we can see that only a minimum percentage of fathers takes advantage of the leave opportunity. This behaviour could be interpreted as an indicator of the secondary role of father in childrearing or, better, as a phenomenon caused by an income constraint. Considering the fact that on average men have a high labour income than women and that parental leave benefits is a wage portion, in the case of maternity leave the cost becomes lower and, so, it seems more convenient.

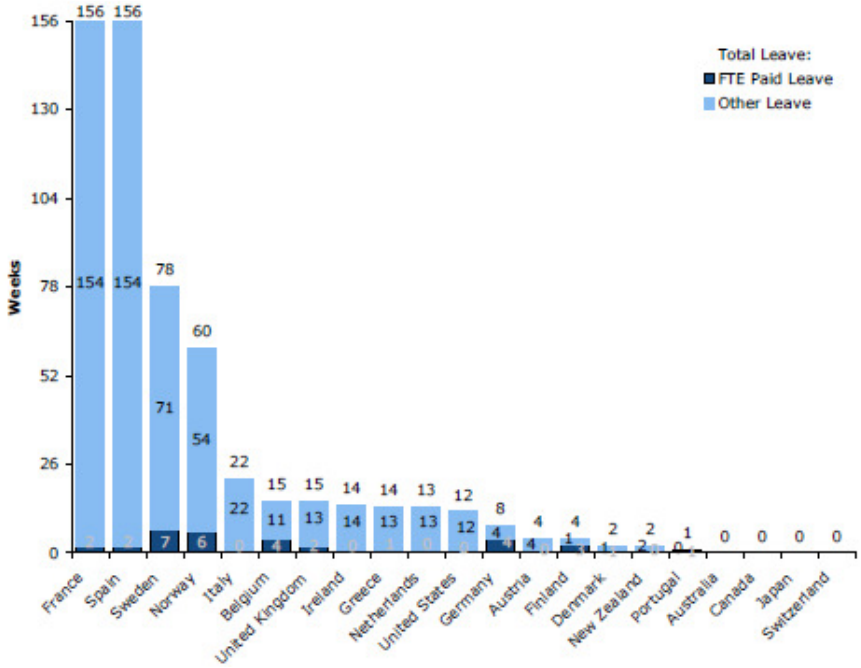


Figure 1.35: Total and FTE Paid Leave for Fathers in Couples, 2008

(Source: Rey R., Gornick J., Schmitt J.)

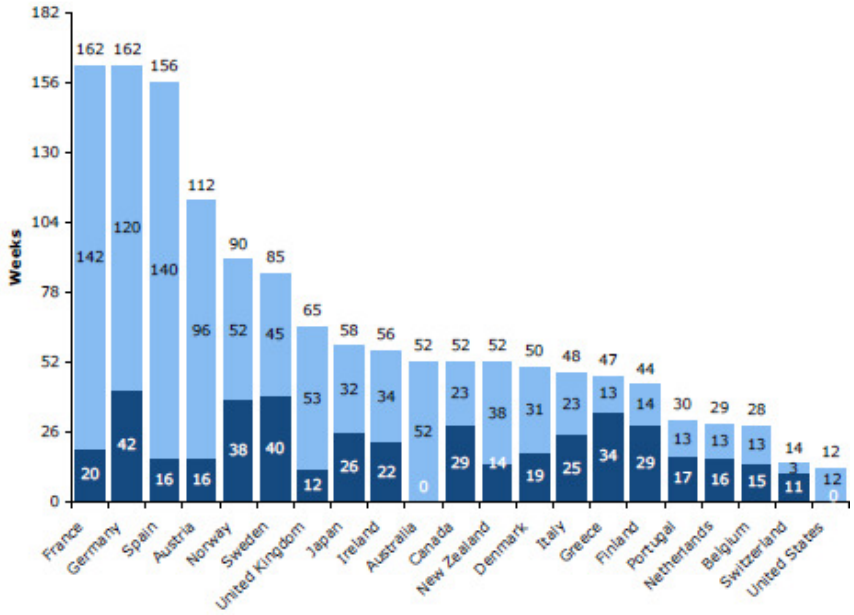


Figure 1.36: Total and FTE Paid Leave for Mothers in Couples, 2008

(Source: Rey R., Gornick J., Schmitt J.)

Generically, we can make a further consideration related to the leave benefits in part-time and temporary jobs. In these typologies of works, in fact, the maternity/paternity

leave regulation is not always guaranteed especially in the southern European countries (where temporary and unstable jobs are increasing) where this was causing delays in marriages and postponement of fertility due to the low coverage in terms of these guarantees. However, since November 2007 the so-called "*atipici*" work contracts have been included into the maternity provision.

For this category, the parental leave is eighty per cent of earnings with no ceiling, i.e. most social partner agreements foresee that the salary will be 100%. In practice this means that the welfare system bears the legal 80% minimum and the company tops it up to 100%.

2. The female figure in sociology

2.1 An historical overview

The majority of women has always worked, having, in this way, a productive function, passing from the slave condition in the ancient times to the farmer one, from domestic workers to the labourer ones within the "concentration camps" of the factories and to the *dominae* of the familiar productive unit, typical of the industrialization period. However, only the existence of a remunerated work that autonomies woman extends the discussion to a social topic.

The right to work, initially, seemed to be limited to women of inferior social classes, remaining forbidden for who's belonging to the favoured ones. The brutal female labour exploitation, characterizing the first capitalistic years, was characterized by the emphasis on the marriage and maternity, seen as the unique possible female activity. Thus, the right to work and parity treatment became the main female demanding of the last century.

The ejection of women from the labour market, especially in the 1930s was sustained also by the fascist regime, which exploited the female labour as a sort of scapegoat both of the male unemployment and of the demographic decrease. Some politics, explicitly, aimed to disincentive the female formal female participation (i.e. the possibility of dismissal in case of marriage).

Considering that this behaviour remained also after the war, the return of women to the extra-domestic and remunerated work could be considered the main phenomenon of the last 40-50 years. We have to talk properly about return because the female presence in the agriculture and in the industrial development was relevant especially during the two world wars, when women substituted fighting men in the factories.

Following the Frey analysis, in Italy, the reduction in the labour force during the period 1959-1966 could be considered a sort of physiological sequel of a process related to the productive system industrialization, that showed a high level of agricultural labour force on the total amount of labour supply; but, this is only a partial explanation.

The economic structure transformations in 1959s had a radical effect on the labour market. Aside from the industrial concentration phenomenon, there was an increase in technical processes, particularly in the “automation” procedure whose rebounds have increased the demand for high-qualified workforce. This phenomenon was linked with many effects, especially on the female employment. While the agricultural sector was featured by masculinisation of the labour force, the industrial sector had a linear trend wherever.

The Italian context shows a particular situation: the ousting of women and men from the agriculture was greater than elsewhere, causing difficulties in the re-absorption of the excluded labour force in the factories.

Women outside of agriculture, particularly, have to look at the possible source of danger coming from the new younger female workforce; for this reason many of them renounced at all to the work finding activity. Others did not come back to the labour market after the absence due to the motherhood. This tendency was also increased by the abundance of male participation, which had always obstructed the female engagement: indeed, the higher female cost discouraged her engagement in presence of male availability.

This phenomenon knew a dramatic increase with the high rate of migration, especially in the Northwest area, also called the industrial triangle. Firms, in order to achieve international competition levels, tended to penalize female low qualified workers, in favour of more qualified employees. If this was the demand structure, the female supply side was totally inadequate, especially considering the qualification aspect: it contributes in forming the pathological, no more physiological, side of the problem.

Due to the fact that women were excluded from the professional formation, they were attested on a lower level of competitiveness with respect to men. This aspect was additionally worsened by the services lack that hindered married and mother women to work and to re-qualify themselves (implying a further difficulty in the re-entry process).

In Italy, for this reason, a phenomenon different from the other countries took place: while women tended usually to work before and after the motherhood, in our country the majority is represented by very young subjects (in these years a quarter of working women is below 25 years old) working only until child birth.

Additionally, if we look at the cohort between 14-19 years old, the situation is even worse: standing on the fact that they were low educated and not so prepared to face high technological works, low qualified at the beginning without re-qualification possibilities afterwards, Italian women were in a very weak position in the labour market.

To study different female participation models, the classic instrument is the curve of activity rate related to particular ages. As said before, until early 1970s there were two typical models: one for the mid-northern countries and the other for the southern Europe. The first one showed a high female presence and the activity rate trend had a bimodal path "M-shaped".

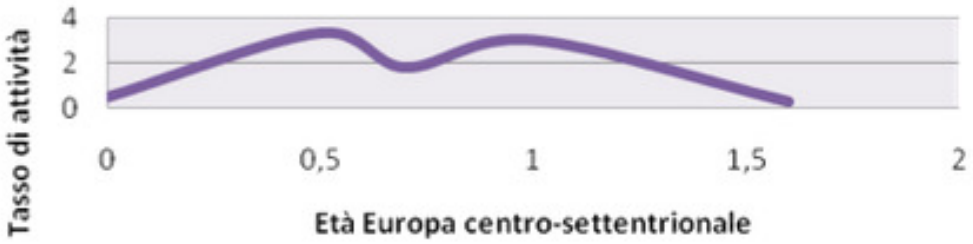


Figure 2.1: Models of female participation to the labour market, divided by age (Source: Reyneri, 2005)

The second one, instead, showed low activity rate and the curve had an "upset L-shape" with only a peak in left hand side, showing a very short female presence until 24 years old and then the exit from the market after childbirth.

Figure 2.2: Models of female participation to the labour market, divided by age (Source: Reyneri, 2005)

The high increase in the female participation in 1970s and 1980s changed the European countries' profiles and, in certain cases, it seemed similar to the male levels. The curve of activity rate, divided by ages, was bell-shaped, with a long peak between 25-50 years old, followed by a decline from 50 onward. In this case we can see that the temporary female presence disappeared.

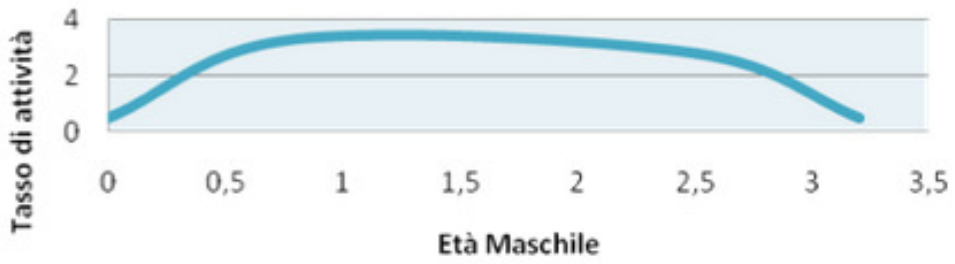


Figure 2.3: Models of female participation to the labour market, divided by age (Source: Reyneri, 2005)

This third model characterized, in the 1980s, also Denmark, but generally the traditional "M-shape" assuaged in Germany, UK and France. However, we have to underline that curves of activity rate give only a static representation, but it is necessary to consider also the dynamic one by looking at the longitudinal profiles of these rates. If we analyse the female condition, we can observe that, while in 1970s women entered very soon in the labour market to immediately exit after the motherhood, in the 1980s they entered later with a higher education level and for a longer period.

By making a further step, in the 1990s, comparing the Italian activity rate with which of other countries, we can note that the differences for twenty/thirty-year-old are reduced, while this is not true for the forty/fifty-year-old due to a sort of generational effect related to the slow increase in the female participation in the labour market. Near this general context, we focus our attention on the different scenarios in our peninsula: in the northern regions, indeed, the young housewife is usually disappeared, while in southern ones this figure is still taken root. In this scenario, the problem is even serious if we consider the fact that the young women presence in the labour market consists in a mere research for a work by opening a deep abyss between

the increasing expectations and the decreasing possibilities in their fulfilment. Until now, it is possible to observe a high young female resistance capability in the labour market (although high unemployment levels) by underlining a strong attachment to own job, becoming a sort of plans for the future. However, we have to evaluate how long a work research could proceed without the overcoming discouragement.

The heavy discrepancy between activity and employment characterizes also the northern regions, even if with less relevance. Here, while for younger women the boost to participation is reduced (by taking into account the real activity performance), for the older ones the strong augment is already accentuated if we look at the employment. The female presence upturn in the Italian labour market in 1970s and 1980s was dominated by an employment growth of those people causing the drop in 1950s and 1960s, so adult women between 25-50 years old.

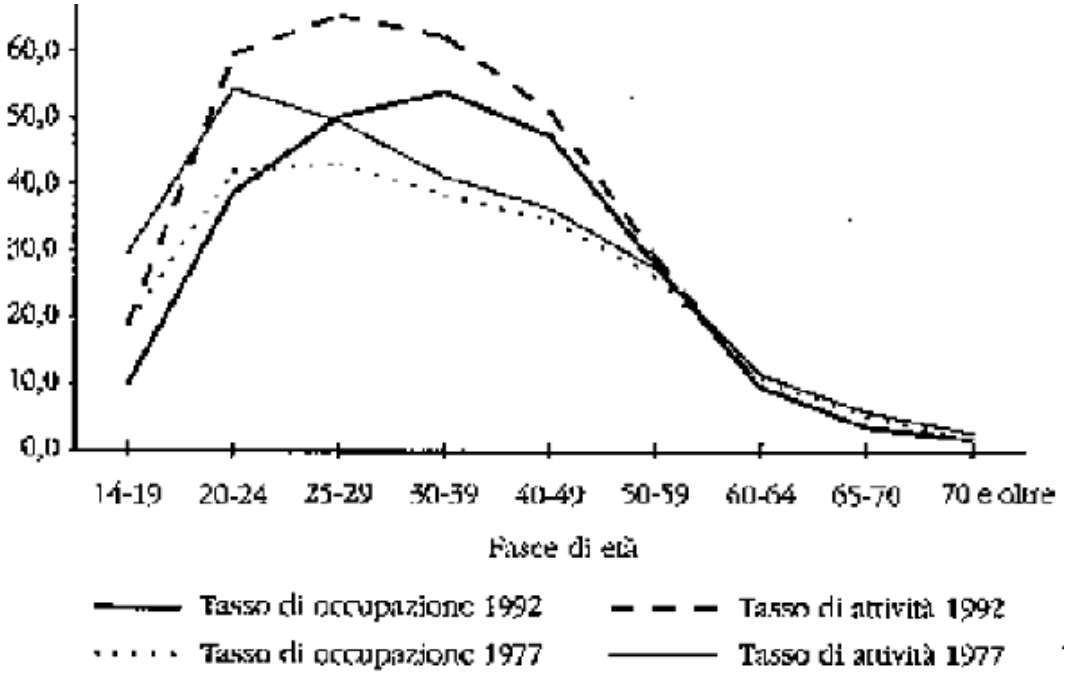


Figure 2.4: Activity and employment rate divided by age in Italy (women, 1977-1992) (Source: Reyneri 2005)

However, in the last period, the female participation was especially linked with agriculture and parental factory implying a more feasible conciliation with the traditional roles division in the family management.

But now the labour context is completely different. At the light of this, the explanation of the demand/supply reinforcement is found in the existence of the part-time opportunity, seen as a sort of driving force for the female employment.

2.2 The sociological role of part-time

Part-time can be seen as in instrument to conciliate domestic and working responsibilities. A wide access to part-time opportunities can allow women to transform their double presence into a more sustainable position, remaining on the labour market also after the motherhood. Although its positive contribute to the female labour participation, part-time can have also negative implications, such demonstrated by the human capital theory. From this last point of view, the lower investment in the work (reducing working hours) makes the interruption lower penalising. This would negatively bear on the female participation rates. Additionally, often the part-time remuneration can be insufficient for the spent in reducing the domestic activities: if it is the case, the part-time becomes a twice-penalising condition, with lower wages and greater work volume.

Lastly, it has to be considered that, even when part-time is a voluntary choice, often it raises the risk of getting stuck in jobs without carrier opportunity. Enterprises invest far less in part-timer formation standing on her higher cost per capita and on the greater disposition to abandon the labour market.

A comparative analysis of the part-time spread is not so easy because it is not a homogenous category in the European countries. This is related to the fact that there are differences in the role covered by this typology of work in the different national contexts.

A first possible index is the number of hours worked by the part-timer. In certain European countries, such as UK, workers are mainly concentrated in low time slots, while in others, such as France and Denmark, in the upper ones. The Italian context is characterized by very long timetables: more than an average of 23 hours with respect to 21 of Denmark and less than 18 in UK. Moreover, in Italy the average full time worker office hour is reduced: more than 36 hours with respect to 38 of other countries. A strong difference in precariousness levels holds: countries, where part-time is most spread, the temporary employment is lower; on the contrary, a strict relationship between part-time and precariousness remains high where this job typology is low spread.

Differences in the juridical and contractual sphere are even more relevant. The extreme case is the UK, where labour protection laws are not applied to part-time worker. The condition is better in Germany and France, even if part-time worker are often excluded by particular insurance agreements. The extreme opposite case is probably the Italian one where the providential and labour legislation is applied in a homogeneous way.

If we consider the part-time spread evolution over time, we note that, in 1970s and 1980s, only in the United States the female full time employment was increased faster than the par time one, while in all other countries was the opposite. In Italian scenario, in the same period, all added employment was female and for the 70 % it was based on part-time job implying an additional increase in this typology of work of 38-45%. Marries women with children constituted the greater part of employed women. Due to a decline in the total male full time employment, the whole employment growth should be considered a sort of substitution of “full” male jobs with “half” female ones, less remunerated and less guaranteed.

The high female employment increase was possible thanks to the unchanged proportion between full time and part-time work. Additionally, always in the Italian context, the amount of part-time female worker was the same for each age class.

If we consider the sectors in which the part-time was most spread, generically the large quota was related to the commercial distribution and in the provision of private services; in Italy, it was mainly spread in insurance services without any trace of it in the public sector, because teachers and public employees were considered full time workers.

Near to these considerations, we have also to look at another problem by asking us whether the part-time employment growth was due to labour demand pressure or to the needs of a particular age group. Moreover, it is even difficult to understand whether a large number of women were forced to accept such job conditions because of the absence of full time works, even if it seems a voluntary decision rather than an involuntary one. In order to sustain the thesis of involuntary part-time labour, indeed, we have to capture the patriarchal ideology based on the fact that at the origins of its spread was found on the roles of both women and men in the family.

In Italy, the scarce creation of part-time positions is primarily due to the economic structure, where small-medium firms prevail with a traditional aversion to the part-time figure.

2.3 The sociological role of grandparents

The presence of grandparents is another instrument to facilitate women conciliation of domestic and working responsibilities due to their fundamental role in looking after children.

Historically, tight relationships between grandparents and grandchildren are a relatively recent phenomenon. The grandparents' role entered in the European languages between 16th and 17th centuries. Before that moment, they were considered only simple ancestors and not very important figure in the family context: indeed, they were not seen as intimate relatives. Grandparenthood is, for this reason, a modern concept born with the bourgeois family of the 18th and 19th centuries, when life expectancies rose rapidly and the age of married women decreased. As a consequence of these changes, the grandparents presence became fundamental and fully developed and recognized only when childhood was acknowledged as a distinct life stage with specific needs: from that moment onward, grandchildren of younger cohorts can expect to spend a longer period of their lifetime together with their grandparents.

The grandparenthood phenomenon, especially in the 20th century, was characterized by a radical change in the population composition due to low fertility rate and high life expectancy shocking the standard family configuration: more generations share more time together, while the size of the younger cohorts becomes smaller, creating, as outcome, a so called *beanpole family*.

Generically, we can say that both European regions and countries have shared common trends in demographic and social development but we have to underline substantial differences among them in timing and degrees with which this happened.

The two world wars, in particular in countries such as Germany, Italy and France, had relevant influence on the demographic developments of the internal families' composition by removing a large share of men in specific cohorts, especially fathers and potential grandfathers. These created large discrepancies in the adjacent birth cohorts: In those years, children were subject to a high risk of losing their fathers and their own children, as consequence, had probably no grandfathers alive.

Moreover, other dimensions had, and have also today, an important role on the experience of being or having grandparents/grandchildren. Among these, we can cite the family composition, the degree of marriage universality and the age at marriage for women. All these elements, in turn, had impact on the behaviours and exchanges between generations.

Contrary to the above-mentioned changes, many other of them affect negatively the relationship between grandchildren and grandparents: many younger grandmothers, indeed, are now employed in paid jobs and, for this reason, have conciliation problems between labour and domestic obligations as their daughters and daughters-in-law. This implies more autonomous and independent activities made by young elderly as long as they are well and healthy, also in retirement period.

Another factor, influencing the negative link among kin, is the higher incidence of family dissolution implying a weak relationship between children and the grandfather related to the parent with which they do not live (noncustodial parent).

The last elements, considered as barriers, are both technological and social progresses that create the prominent image of old-fashioned grandparents.

2.3.1 Different types of interaction between grandparents and grandchildren

Studies generally distinguish between three types of interaction: direct, indirect and symbolic.

The direct interaction includes quite different ways of exchange between grandparents and grandchildren. The most relevant is the instrumental and material support through money and care contributions: when grandfathers spend time with their grandchildren, in fact, they become an observational guide model able to give advices and to solve problems.

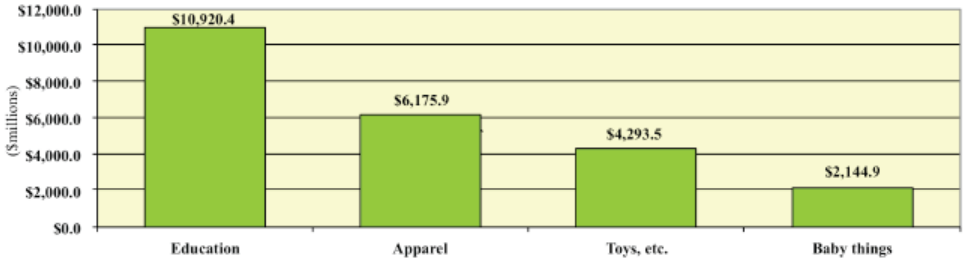


Figure 2.5: Estimated direct spending by grandparents for benefits of grandchildren USA, 2009 (Source: Bureau of Labour Statistics annual Consumer Expenditure Survey)

The second type of interaction, the indirect one, rises up when direct exchanges involve grandparents and grandchildren's parents: a large part of cash flows from grandparents to grandchildren are effectively an indirect helps for their parents. The same happens when grandmothers help mothers with household chores, indirectly, allowing them to spend more time with their children. Thus, we can note that, generically, grandparents can be an important figure in the family conciliation problem.

The third aspect is the symbolic one: the fact that grandparents "are there" contributes to a richer family life. Their presence underlines the multiple forms of obligations and membership, which constitute a family specific history. This aspect is important particularly when both grandparents and grandchildren careers may last many years and go through different phases, therefore requiring continual re-elaboration.

Additionally, we can look at a reverse perspective: at what grandchildren provide to their grandparents. Apparently, they cannot do much but, concretely, they give a large contribute to the health and well being of their relatives.

2.4 Juridical Context: from parity to equal opportunities

The first juridical contribute in the Italian panorama raised in 1902 with Carcano Lex, the first regulation based on the female labour force (that forbade women under the table job, recognising the maternity leave). This disposition produced, in that years, a duplex effect: on one side, it contributed in excluding woman from the labour market; on the other, it strengthened the female role in the domestic context. This tendency would remain constant for the most part of the subsequent historical period, especially during the fascism, when women were included in the minor labour category (the so called half forces).

The constitution emanation fundamentally contributed to a radical change of the female figure in the juridical context. The Article 3 expressed the prohibition of discrimination based on sex, it was correlated with the Article 37 that stressed the female protection, stating: "Working women are entitled to equal rights and, for comparable jobs, equal pay as men. Working conditions must allow women to fulfil their essential role in the family and ensure appropriate protection for the mother and child".

Especially during 1970s the maternity/work issue was fundamental topic in the industrial development and in the feminist movements. In these particular contexts, was approved Law n. 903 that would remain a key point in the female labour legislation.

Simplifying the contents, several parts can be identified:

1. Rules to ensure the parity of treatment;
2. Rules to guarantee the parity in carrying out of the work;
3. Rules devoted to reduce employees' difficulties and the female labour costs;
4. Rules to match new female labour discipline to the new family laws.

Even if the law established the formal parity principle, it did not be able to act in a practical sense to match formal and substantial parity.

The attention for the indirect form, a typical feature of the development of the discrimination concept during 1980s, led to the promulgation of Law n. 125/1991. Its

fundamental contribute stayed in underling the transit from the parity concept to the equal opportunity one, providing some practical instruments to achieve this goal.

A further contribute was added in 2000, with Law n. 53, that provided disposition for the maternity/paternity sustain, trying to answer to the need of conciliation between family and work.

The main novelties introduced were:

- Flexibility in the temporal distribution of the 5 months of compulsory maternity leave;
- Recognition of a right to the fathers to obtain paternity leave, independently from the labour condition of the woman;
- A greater flexibility in the use of optional leave;
- Elimination of limitations of the absences due to children illness;
- Introduction of other types of leaves for familiar reasons;
- Economic incentives to the enterprises that realise policies to make the conciliation easier.

Although its complexity, the 53/2000 was fundamental in two main aspects: introducing greater flexibility related to the employees' need, no longer based on the firms desires and encouraging women not to abandon immediately the work whenever the familiar weight increases.

In 2007, through the directive entitled "*Measures to actuate the parity and the equal opportunity between men and women",* the point on the need for the respect of these principles in the creation of the new jurisprudence was stressed.

Lastly, Legislative Decree n. 5/2010, modifying parts of the previous cited contributes, aimed to remove, also through positive actions, all the obstacles concerning job and carrier opportunities to obtain the parity treatment between men and women.

2.5 The feminization of the labour market

2.5.1 The supply side

In the second half of 1970s the increased female employment was inserted in the development of a secondary labour market, featured by decentralization processes, small firms utilizing temporary work that tries to solve the rigidity of male supply, reducing the working cost, weakening the union powers and by domestic job.

The last one was particularly spread in the catholic field as an ideal work opportunity for woman, permitting her to earn something and, at the same time, looking after children. Particularly diffused in the clothing industry, it can be interpreted as traditional labour, but exploited with the modern capitalistic instruments; often with self-financed machineries, without insurance coverage and with a low contractual remuneration. Working at home is not a favourable condition, involving children in the labour process in order to increase the productivity that has to follow the industrial rhythms.

Properly during these years, the stereotype of a marginal and weak female labour force (featured by discontinuity, low devotion to work, availability only for reduced working timetable) was born, representing women as subjects not really interested in a regular professional integration because of their traditional role in the family.

Analyzing data, we can affirm that during 1970s the female participation in the manufacturing industry increased in correspondence of a reduction in the male one and changed its shape, especially for the even numerous high-qualified women.

The female participation was no longer limited to declining sectors but oriented to those that are in expansion: a feature particularly spread in Italy, where (as the other southern European countries) the part-time labour was not so spread.

The increase in female participation was focused on the tertiary sector (reaching in 1990s more than the 40% of the total employment) or at least on the secondary one, that lived a sort of “tertiarization” process. Its fundamental role was already present in 1970s, when the female participation rate for age classes in third sector (differently

from the agriculture and the manufacturing ones) already showed the subsequent typical upset L-shape.

2.5.2 The demand side

Considering the demand side, the data are less articulated, implying a less accurate picture of these years, about which some comments are, in any case, possible.

Until 1992 almost 30% of the employed women in the third sector was related to the commerce, restaurants and tourism: we are speaking of saleswomen, waiters, interpreters, employees in advertisement agencies. The roles of banks and insurances were particularly relevant in increasing the female participation and the 70% of new employees in these sectors in that years were women.

Lastly, more than half of the new female occupation was focused on public administration and other services, such as the provision of independent and autonomous work.

Especially in the public sector, the selective mechanisms (competitions) are more formalized and indifferent to the gender qualification. The most explicative case is the competition for the access to the legal-bench: in less than 20 years the female winners had passed from 8% to 53%. Usually, in this type of activity, universalistic procedures of entering were accompanied by a non rigid organization of the working time (the full-time work consists in a reduced period of 36 hours or 23-30 hours in the case of the schools). In almost all southern European countries, the “reduced” working hour seemed to substitute the part-time provision in augmenting the female participation to the labour force.

At the light of these data, it is not difficult to understand the fundamental role of the third sector in women emancipation: the majority of these services are only a form of activities’ professionalization that, before, were made exclusively in the informal familiar context (for instance assistance to elderly people or to sick ones and the childcare and primary education). In a sort of sense, the female labour supply was originated as a portion of its own demand, because women needed to require to the State or to private market the provision of services to reduce their duties in the family

context, encouraging a sort of virtuous cycle. On the other side, the decrease in childbirth due to the greater female participation to the labour market reduced the demand for services for the infancy (where the majority of women are employed), decreasing also the demand for working women; however, it is forecasted that this effect will be balanced by the increase in importance of women in the care of elderly people, that shows, day by day, a greater relevance, since the demographic composition of our country.

The gender stereotypes are not only diffused in the working perspective but also since the female formation: the educational female choices are focused on humanistic patterns; only when this type of choice becomes an obstacle to their carriers, women are encouraged to approach to a more scientific education. The orientation to the job carrier is particularly stressed for those girls that are daughters of working women, implying a sort of multiplier effect from a generation to another.

If, on one side, the female stereotypes have increased the new demand in services provision, on the other, discrimination with respect to the female labour force has always existed, due to the risk of greater absences' unpredictability and frequency and of a major discontinuity in work activities.

This would imply a question about a possible change in the entrepreneurs' opinions, in the last years, by doing themselves more sensitive to the features and to the needs of the female labour force components. Unfortunately, the answer is only partially positive.

The female occupational expansion is focused on the northern regions, where the relevance of new male forces is decreasing and men, in adult age, do not hold adequate features for the third sector demand; different the situation for the South, where the male competition is greater and the female participation had cost of lower retributive levels.

2.6 Education: cost or investment

Starting from the end of 1970s a dramatic increase in the high school participation characterized the new generations. As in many other fields, the recovery of a consistent historical delay happened with high speed: to be more explicit we can underline that in 1977 more than one third of young people (between 20 and 24 years old) achieved a high school qualification, whereas looking at whose were born only five years before the percentage decreases of one fourth. The situation gets worse in correspondence of people born 15 years before, showing education rate around 17%, whose majority did not achieved nothing more than primary school qualification.

After the jump onward of the educational curve, we can observe an increase in the subsequent years (the 90s generations are more qualified than the 70s ones), even if especially for men the increase become slower and near to a levelling-off.

Looking at 1990s, the ageing of the generations that assisted to the increase in the qualification causes an augment in the percentage of educated thirty/forty-year-old, whereas the qualification level for the fifty/sixty-year-old remained relatively low.

It is predicted that 15-20 years will be needed to solve the disequilibrium in the different educational levels among the Italian age classes, with serious side-effects on the youth unemployment: the result is particular warring standing on the fact that it is shown that Italy (the unique country with Greece to have maintained the compulsory education to 14 years old) has stored, in these last years, another delay with respect other European Countries because of its exclusion from the higher education rate increase.

However, looking at the gender distribution in the increase of educational level the women performed better than men, surpassing them at the end of 80s, with a serious impact on the activity rate tending to show a positive relationship with the education level achieved.

Additionally, the housewife percentage decreases gradually but at an increasing speed from subjects with only a primary education to those with a secondary one.

As depicted by the Figure 2.5, representing the features with respect to age classes, we can observe that in 1992 less than 17% of primary educated women were in the labour

market, whereas this rate achieved 42% in case of an upper formation level, touching 82% in case of graduated subjects.

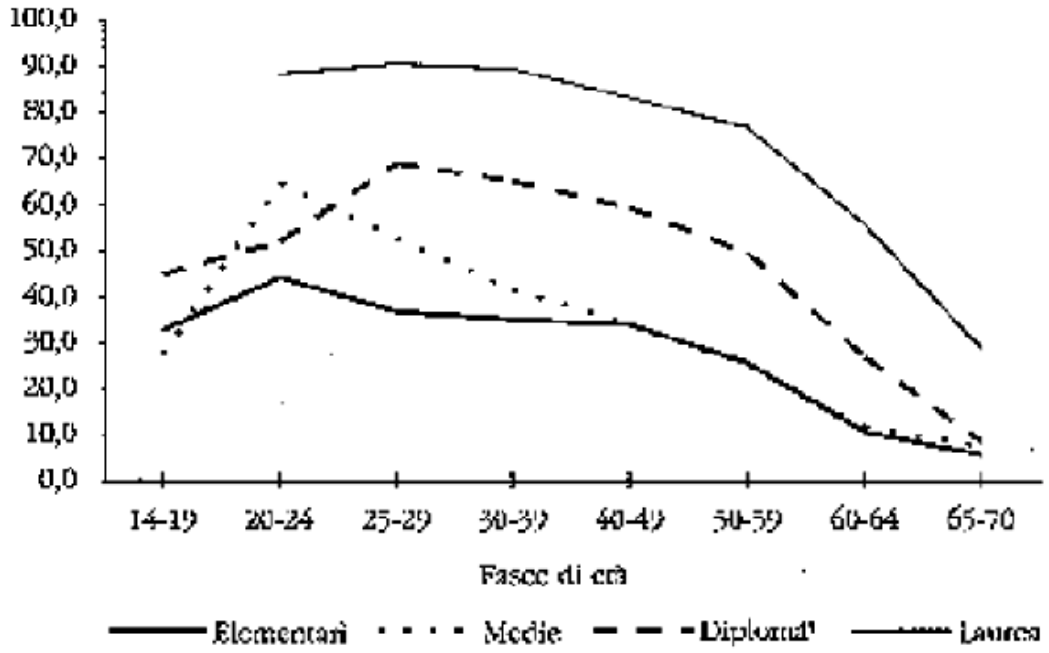


Figure 2.5: Female activity rate for age and education level, 1977 (Source: Reyneri 2005)

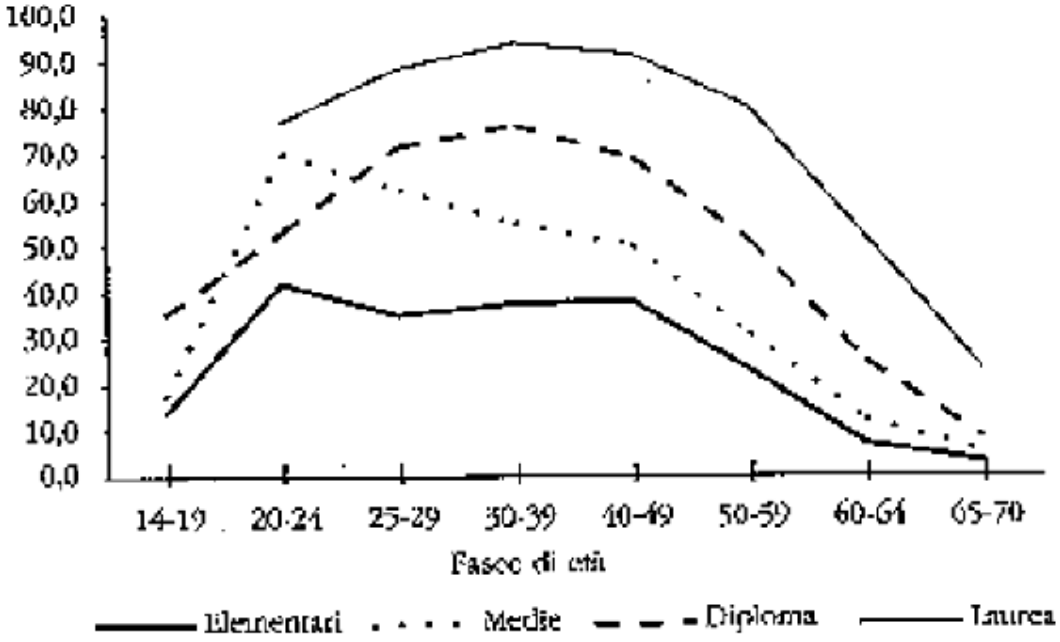


Figure 2.6: Female activity rate for age and education level, 1991 (Source: Reyneri 2005)

Going more in details, until 24 years old the activity rate of educated women was maintained low by the school frequency, then in order to capture the phenomenon could be more relevant to look at adult women: between 25-49 years old, the activity rate of graduated women is more or less double with respect to that of women with only primary education.

Especially referring to the 1992 picture, we can see:

- The spread of the bell-shaped participation for the graduated women: they show a considerable presence in the labour market also after the marriage and childbirth phase, remaining constant until the retirement event (the curve underlines a substantial correspondence with the male one, at least until the 50 years, when the female retirement process proceeds more rapidly than in the male case);
- Persistency of upset L-shaped traditional model: participation rate relatively high during the early youth, with a subsequent and gradual neglect in correspondence of the family event.

Comparing the two pictures, the fact that the growth of the female labour supply in 1970s and 1980s was more or less totally due to the increase in participation rate of graduated women can be more easily understood: two third of the augment in female labour supply is mainly due to the increase in the educational level.

This positive relationship existing also in other countries, such as Germany and US, can be interpreted following many points of view.

For the economists, the different behaviour of women could be explained throughout the human capital theory. In this view, the high “schooling” would urge women in searching for a job since they are young but also in preserving her position in adult age, since that the education is considered as an expensive investment. The greater is the length of educational pattern, the more expensive the investment and the more the pressure to preserve the found job.

For the sociologists, on the other hand, the emancipation can be attributed to the role of school: women find in it new values and new behavioural patterns, no more she has to sustain the idea of passing from the psychological subjection to the parents from one to the husband. The greater is the formation level, the higher the hope for personal autonomy, realized through the job instrument.

Both aspects, in a sort of way, coexist if we think that, at the end of the formation period, there are two different points of view: one, in an economic perspective, from parents, that desire a sort of re-payment for the concluded investment; the other, the sociological one, from women themselves, that want to obtain the independence from the male gender.

In adult age, the choice of carrying on being a component of the labour force can be explained by the desire to transform the educational investment into a profitable return, especially when the work position is well qualified and satisfying: then, when women make the choice between staying on the market or looking after the family full-time, the economic interpretation appears mixed with the sociological one.

Considering the causes determining the increase in female participation in the education process, further with respect to the one individuated in the greater living standards achieved by families, we can underline the concept of social mobility. As shown by some research activities, if in the past this mobility took place thanks to the marriage, nowadays great social inequality within a couple is no longer perceived as possible, then the educational investment becomes a fundamental instrument in improving each social position. Since qualified job opportunities are more than unqualified ones, the opportunity for occupational mobility is defining also for women and no longer only for men.

Additionally, the positive relationship between education and participation can be individuated with a comparison across Italian regions: in the South, the educational levels are inferior for both male and female subjects: the premature educational isolation can be considered one important feature of the poorer generations. More in details, an extreme polarization of the phenomenon can be underlined: graduation rates similar to the North, primary level percentage far less diffused than in the North. Mainly, this delay with respect the Northern Regions can be addressed to the economical backwardness of the area and to the survival of traditional familiar strategies.

Nevertheless, in these regions more than in the mid-northern ones, the increase in female labour force registered around 1980s was strictly and greater than that in the other regions, related with augment of education spread.

Being or not educated matters a lot for Southern women in the emancipation procedure from the family: a higher educational qualification is required to achieve the ambition of a job position, especially in world where the prominent position is the unemployment.

2.7 About segregation

Until this moment we have affirmed that the expansion of the female labour participation is strictly related to the augment in the demand for positions exclusively feminine and it seems to protect them from the male competition.

The other side of the coin consists in the segregation phenomenon, or in the concentration of women in sectors where they are dominant and where they are excluded from the fields typically "of male dominance". Considering also that the female occupations would be generally worse that the male ones in terms of wages, career opportunities and work conditions, this segregation could become a "ghettoization".

This picture is also confirmed by the fact that the segregation levels remain stable over years in all developed countries, even if the Italian situation is much more complicated, due to the data shortage.

We have to distinguish between the horizontal and vertical segregation. The first one is related to the position of the subjects in the hierarchical levels, whereas the horizontal one (more used in the cross-countries comparisons) is related to the concentration in job positions and in sectors.

The common statistical measure is the "dissimilarity" index, whose value captures the female (or male) portion that should change working sector in order to achieve an equal distribution in terms of gender in each sector or occupation. This index, created 40 years ago, is also subject to many critiques mainly based on different elements: the female occupation portion, the aggregation level of the areas and their different relative dimension. Indeed, the less is the female portion and the more the aggregation level, the lower the dissimilarity index, even if a real lower segregation is not individuated. If the standardization of the index allows solving the first distortion source, the other remains especially in the international comparison context.

Probably due to this distortion mechanism, a strange result emerges: countries, considered as being on the cutting edge for the female labour participation (as Sweden, Denmark, Norway and U.K.) show the higher segregation indexes, whereas the lower levels are attested for countries such as Italy or Greece.

Charles (1992) showed that the importance of the third sector is a determinant cause of the female segregation, while lower fertility, a higher augment in the total employment, a more consistent egalitarian ideology on the gender differences matter a lot in affecting the lower level of female segregation.

In this panorama, Italy is concerned as a backlog country, without an irrelevant third sector and with a consistent portion of independent workers. However, this explication seems to be not so satisfactory; whereas, probably, the most relevant cause of the extremely low segregation level in Italy has to be found in the low birth rate and in the limited diffusion of the part-time.

The relationship between part-time and segregation is confirmed by many empirical analysis: when the female occupation augments thanks to the spread of part-time, also the segregation level augments, whereas when the full-time employment increases the segregation diminishes and the female presence augments also in the male positions.

Since that, in almost all countries, the increase in female participation is due to part-time opportunities, the fact that the segregation can be interpreted as a sort of "retaliation" for an increase in participation of women is confirmed.

Considering the career opportunities, two plausible reasons to believe that for a woman getting ahead is more difficult to be engaged exist.

Firstly, even in the more formal contexts, career takes on requiring high investments on term of time and availability, not well coinciding with the double presence model suggested by Aburrà. The businesswoman is forced to respect male models of full-time participation.

Secondly, the mechanisms to proceed in career depend largely on cooptation and social relationships, that traditionally are more consolidated in the male sphere, since the historical and economic role recognized them to man.

Finally, we can affirm that in correspondence of an even lower horizontal segregation we can find an even stable vertical one.

There are several different theories about the possible explanations of segregation phenomenon: the first, focused on the supply-side story was developed both by the sociologist and economists; the second one, followed by economists points out on the demand-side.

2.7.1 The supply-side sociological story: *Socialisation*

The simplest socialisation thesis affirms that cultural transmissions create different preferences, interests and aspirations in males and females. These imply that men and women apply for different jobs. This view is quite sociological but, at the same time, is unpopular among American sociologists of gender. This, probably, is due to the fear that socialisation theory seems to blame the victim and can be used against attempts to get employers to stop discriminating. It appears that women want what they get. Another reason is that sociologists have the desire to differentiate their theories from those of psychologists, or alternatively, a further explication can be found in the emerging popularity of the "doing gender" perspective, emphasising that gender is something we actively do, not something socialised once and for all.

From this point of view, "each of us is held accountable to make sense to others in terms of gender norms, even if none of us actually prefer or believe in the rightness of the norms."(from England P., p. 269)

However, it is difficult to choose between the internalised socialisation view and the "doing gender" one. Whatever is the chosen alternative, the supply-side mechanism seems to be adequate. The best evidence for this last point can be found in the fact that males and females aspire to very different jobs and educational careers: even if the impulse towards care work, among women, is probably due to a historical heritage, there exists a little evidence in favour of female appeals to this fields probably because they think that they will be easier to combine them to their future mothers' roles. Gender differences have diminished greatly when women increasingly have started choosing male fields of studies and jobs.

2.7.2 The supply-side economical story: motherhood-related explanations

Economists try to explain the segregation problem with the human capital theory. Starting from the fact that men and women seem to have same education levels, it is difficult to explain why they make different choices in evaluating their fields. In many

cases these typologies of choices are related to a female lifetime earning, instead of a real money-related motive: women, indeed, plan breaks for childrearing by choosing jobs with low human capital depreciation during years away from job.

A related argument is that jobs offering on-the-job training will have lower starting wages but steeper wages' increases with the passing of the working years. If this is true, women probably taking into account the possible future break, would choose jobs with higher initial wages but flatter evolution path. If this can generate segregation, one should find higher starting wages in female jobs; however this does not find evidence in the empirical researches.

Given that economists' thesis, linking women's mothering responsibilities with selection of jobs that penalises intermittency less than other one, does not have a countercheck in the reality, we would implement these analysis before concluding that motherhood responsibilities and segregation are strictly related.

2.7.3 The demand-side story: discrimination in hiring/placement

Near to the previous explained theories elaborated focusing on the supply-side of the labour market, a further explanation of the segregation phenomenon could be based on the labour demand-side taking into account the different employers treatments towards male and female applicants, preferring consciously or unconsciously men to women.

Despite many researches based on this approach, we have obtained very few results, related to the discrimination coming from the employers. Generally, the problem sorts out from the fact that, usually, the surveys ask people about the jobs they hold and not about those for which they applied.

What is the employers' motivation for engaging in hiring discrimination that perpetuates segregation? We can underline two main hypotheses, covering both economical and sociological supply-side theories of segregation. The first one is that employers can be slaves of arbitrary and socially constructed notions of which gender is appropriate for a specific job.

Many economists reduce the emphasis about discrimination because neoclassical theory implies that it should erode in competitive markets. However, there are two different typologies of segregation-encouraging actions done by employers that economists think to have relevant power. The first one is related to particular policies using some hiring criterion other than gender, which gets more productive workers, on average, but having, at the end, a strong gender effect. Economists do not consider them as discriminating because they define discrimination in terms of treating equally productive workers differently. However, such policies take away from the market more women than men.

The second one, instead, can be considered a statistical discrimination: starting from the fact that different groups with different productivity levels exist and that the measure of these last before hiring could be very expensive, employers use these groups formed by informal or formal data gathering to make predictions about individuals. Following this reasoning, all women would be treated like the average woman and all men like the average man. For the economists, this lead to only different gender pay gap degrees commensurate with the average productivity gap, although some individuals probably will have pay inconsistent with their capabilities. Additionally, they think that this discrimination may have no effects in competitive markets, as it may be profit maximising for employers.

The motivation for statistical discrimination is similar to one for requiring facially neutral credentials for all kinds and both involve by using statistical averages. Especially in the second one, the goal is to get workers that are on average mere productive using, in this procedure, credentials. In many cases, the difference between requiring these credentials (having a dramatic gender effect) and using statistical discrimination is not at all a simple motivation but, more precisely, a legal status, sometimes considered illegal.

When such discrimination is used, it should occur especially in jobs for which men are more likely to have the skills than women with the same educational level. A further difference is the childrearing responsibility under the women supervision. Even if employment became more continuous since 1970, women still spend much time not employed or employed part-time than men. Thus, economists' thinking about statistical discrimination has focused on how employers should answer to the

possibility of women leave their jobs for childrearing. In this case, an information problem for employers emerges because rarely women reveal their intentions for the future: in this situation, believing that on average more women than men will leave their job for children reasons, employers will favour men in those jobs requiring higher on-the-job training costs. The discrimination is a profit-maximising response of employers to the statistical generalizations obtained thanks to observable data. In particular, a research conducted by Estévebez-Abe, based on the differences in tendency to use on-the-job training versus that provided by educational institutions, proves that nations with more on-the-job training are more likely to feature employers who engage in such statistical discrimination against women. Although the statistical generalization gets it wrong for many subjects (if they are close to accurate) one can see how it is useful for employers to continue to use them.

2.8 Being outside of the labour market: the housewife

The assumption of the full-time housewife role appeared as behavioural model only around the end of 1950s and during the first half of 1960s, in correspondence of the first Italian well-being. This last created a consistent stable employment, especially on the male side, that was sustained by an increase in the recognition of social rights related to the worker condition.

The professionalization of the housewife figure is a typical feature of these years: on one side, as a transformation of the consumption familiar goods, producing properly an added value; on the other, through the relatives' care.

Thus, the housewife figure knew particular spread in the 1960s when motherhood was seen as the pinnacle of the female achievement and the role of housewife become something absolutely normal and natural, while the ideology, perpetuated through medias stressed the desirability of domestic sphere.

In these years, the valorisation of the female figure passed through an exclusively private role, such as the family fulcrum. Media stressed the idea that the female happiness was strictly related to the familiar context, putting in a closet position her potential work.

Even if in the last years important phenomenon in reducing the importance of the housewife figure (such as the transition of part of housewives to students or retired subjects) has taken place, its role remains relevant especially in some parties of our Country.

Looking at the South, the figure of temporary or definitive housewife continue to be relevant in the social structure; there can be found two fundamental reasons in explicating this event: firstly, the lower formation level and secondly, a lower participation rate to the labour market.

Surely, the development of the domestic technology, particularly the household electrical appliances spread, has lightened the physical effort in the domestic affairs; but if it has allowed women to do in home what previously has to be done outside, it has also changed the life standards (larger houses, richer menus, more sophisticated eating habits) also requiring more labour.

Until 1970s, the housewife figure was prevailing as well-being indicator, not because more husbands allowed their wives to not work but because more families had further resources, high qualified workers, matching her not remunerated labour with the monetary earnings coming from husband. The economic relevance of the housewife role was claimed for the first time from the feministic analysis, only recently recognized by international organizations, as ONU, and granted by jurisdiction.

Probably the less appeal of this activity and the boredom, deriving from it, do not derive from a "forced inactivity" but from a repetitive work, without any personal satisfaction, with an inexistent social value. The domestic work is recognized as necessary, in that produces "use value", but not longer socially productive since it has not "exchange value".

In the matter of this last point, could be cited Lenin that in its L'emancipazione *della donna* wrote that the female emancipation took place only if she would free from the degrading weight of the kitchen and the child rooms.

2.9 Family and Work: conciliation problems

Starting from 1990s, after the family and labour market transformations the interaction between labour field and the familiar ones are inserted in a conciliation problem, based on duties' division between the two gender competences.

In Italy, the relevance of the family in the labour supply definition has been the object of several researches sooner than in other countries. At the beginning of 1970s, from the analysis of the female employment, May (1973) has proved the mirror image between the different presence of men and women in the labour market and in the familiar work.

An US author has talked about the *work-family* system, related to the intertwining between work dimensions and family organisations, as a sort of interdependencies no longer as two separated worlds.

Proceeding historically, we can analyse the first model called *male breadwinner* implying a husband focused on the remunerated working side and a wife limited to the familiar sphere.

However, thanks to the recent socialization processes, the female figure with two roles (remunerated and familiar one) is spreading over day by day. This new female participation to the labour market has meant the collapse of the traditional male breadwinner model, based on a stiff sexual division of work at least referring to the revenues achievement. This implies that not only less women exit from the labour market in correspondence of marriage but also that, especially in western countries, mothers' participation increases. This can be translated in an augment of couples with two earners: at the end of 1990s the *dual earners* couple is the prevailing model, except few countries in the Mediterranean area.

In Italy the double participation family, although not yet prevailing, represents a developing model already dominant in younger couples. The percentages are dramatically higher on the mid-northern regions, where the unemployment rates are lower. The families with two or more earners represent more than 55% in the North-East, 52% in the North-West, 47% in the Centre and the 83% in the South. Standing on

the fact that the higher are the female education and the female labour participation, the dual earners model is more spread among more educated couples.

Many studies on the double careers model show the stress level of the family components: we can talk about *time conflict*, or better about how allocate scarce time between remunerated and familiar work. From these researches, it emerges that wives reorganize easier their priorities to match these last with the familiar time requirement, whereas husbands tend to privilege labour world. After all, only the working mother figure is recognized and protected from the juridical point of view, while the father one has been recognized only recently and not yet in all countries.

2.9.1 The time allocation

A pioneer research, done by Carmen Belloni (1984), has proven that the time allocation was strictly related to the social times external to the family context and strictly influenced by sex, age and position of the family itself. This would imply that the family is the place where an equilibrium between different requests coming from outside is sought, and where compensation between different times allocation of members takes place.

Although the partial retirement of the housewives in favour of the labour market, the Italian family is characterized from a huge division of the familiar labour, gender based. Women bear the greater weight of the domestic work, independently from their position in the labour market: even if working women do not devote the same time of the housewives to the domestic work, this reduction seems to be not compensated by greater husband participation.

From this point of view, the marriage can be seen as the fundamental mean to allocate the familiar responsibilities. While the presence of a working wife considerably increase the probability for the man to have a reduced working day, on the contrary, the remunerated work of the wife has a low probabilities to influence the husband collaboration in the familiar activities.

The reduction in the domestic worked hours amount, displayed by many studies, probably is not due to a greater marital cooperation but to a voluntary reduction of women themselves: through a reduction in children number or a change of the standard lives.

The children presence, referring to Italy, has opposite sign for women and men: it reduces time spent by women in the remunerated work, while it increases working time for men.

3. Agent-based Model

An agent-based model (ABM) is a class of computational models for simulating the actions and interactions of autonomous agents (both individual and collective entities such as organizations or groups) with a view to assessing their effects on the system as a whole. It combines elements of game theory, complex systems, emergence, computational sociology, multi-agent systems, and evolutionary programming.

Before starting with the description of their typical features, it has to be made a further distinction between the ABM models and the multi-agent ones: the first category is large-population models that provide a finer-grained model of the process, with many parameters that can impact on the dynamics. We call such programs, which explicitly model the individual agent-based agents, agent-based simulation models (from Shoham Y., Leyton-Brown K., p. 230).

These models, based on the conceptual unit of the agent, have several common features generally recognized in the literature related to this topic.

The first one is the autonomy of the agents who are units, capable of processing information and exchanging these with other agents in order to make independent decisions. They are free to interact with other agents, at least over a limited range of situations, without affecting their autonomy.

The second feature is the heterogeneity thanks to which agents can develop as autonomous individuals; groups of agents can exist, also if they are spawned from the bottom-up, amalgamations of similar autonomous individuals.

Another one is the activeness of agents due to their influence in the simulation.

The additional following active features can be identified:

- **Pro-active / goal-directed**: agents are often goal-directed, having target to achieve with respect to their behaviours.
- **Reactive / Perceptive**: Agents can be designed to have awareness: they have a 'mental map' of their environment.
- **Bounded Rationality:** while the rational-choice models, generally, assume that agents are perfectly rational optimisers with unfettered access to information, and so capable of deductively solving complex mathematical

optimisation problems in order to maximise their well being, in this case agents can be configured with 'bounded' rationality,

- **Interactive/Communicative**: Agents have the ability to communicate extensively,
- **Mobility**: Agents can roam the space within a model,
- **Adaptation / Learning:** Agents can also be designed to be adaptive, producing Complex Adaptive Systems (Holland, 1995). Agents can be defined to change their state depending on their current state, allowing individuals to adapt with a form of learning, but not necessarily in the most efficient possible way.

3.1 Advantages

We can recognize, in comparison with traditional model techniques, many advantages of the agent-based simulation: 1) it captures emergent phenomena; 2) it provides a natural environment for the study of certain system; 3) it is flexible.

ABM captures emergent phenomena. Emergence is a phenomenon unfamiliar to the classical science, such as chaos and adaptation characterizing complex systems. By definition, an emergent phenomenon cannot be reduced to a system part because the whole is more than the sum of the parties. The study of the phenomena featured by interaction among many components is knows as labelled "aggregate complexity". Referring to the Manson definition, the complexity includes two different aspects: the algorithmic one (in which the complexity lies in the difficulty faced in describing system features) and the deterministic one (in which the unpredictable characters refer to the sensitivity, based on the initial condition). An example that could be more explicative is taken from Caste and Crooks (2006) working paper, where is affirmed that "a traffic jam often forms in the opposing lane direction to a traffic accident; a consequence of 'rubber-necking'".

Standing on the difficulties of their prediction, the purpose of the aggregate complexity is understood through the reduction of the features of the agents.

ABM provides a natural environment for the study of certain system. Referring to the traffic jam example, ABM offers the opportunity of seeming closer to the reality. Using the ABM model can be preferred when:

- The behaviour of individuals cannot clearly be defined through aggregate transition rates;
- Individual behaviour is complex;
- Activities are arguably a more natural way of describing a system than processes;

- Validation and calibration of the model through expert judgement is crucial. ABM is often the most useful method to describe what is happening in the real world (the experts can easily connect to the model).

ABM is flexible. The flexibility can be observed in different dimensions: the ability to change level of description and aggregation or the provision of a natural framework for tuning the agents' complexity (behaviour, degree of rationality, ability to learn and evolve).

3.2 Weaknesses

After having considered several advantages of ABMs, we have to focus our attention on their possible weaknesses. Among them, we can cite:

a) The difficulty in interpreting, quantifying and calibrating the outputs of a simulation related to a system based on agents evolving with irrational behaviours, subjective choices and complex psychology;
b) The low capabilities in modelling large systems and the difficulty of systematically exploring the entire set of possible hypotheses in order to reach the best explanation: indeed, models, by definitions, can consider systems at a disaggregated level, involving the description of potentially many agent attributes, behaviours and their interaction with an environment. The only way to approach to this problem type is through multiple runs, systematically varying initial conditions in order to assess the robustness of results. Properly at this point, the limitations appear because the process of checking the robustness can be computationally extremely intensive and time consuming, in particular considering the case of large systems;
c) The low reasonableness in the real world of a large variety of surprising behaviours exhibited by mathematical and computational models;
d) The difficulty in understanding them without a good knowledge of the program used to run the simulation;
e) The need of carefully check activity of the computer code in order to prevent inaccurate results due to coding errors (however, we have to say that anomalies can be interesting and not always are related to programming errors).

3.3 The key figure in ABM models: John Henry Holland

Related to the topic of the agent-based model, we can cite the first time in which the word “agent” was used is in 1991 by John Henry Holland in his paper called “Artificial Adaptive Agents in Economic Theory”.

John Henry Holland is an American scientist and Professor of Psychology and of Electrical Engineering and Computer Science at the University of Michigan, Ann Arbor. He is a pioneer in complex systems and nonlinear science. He is known as the father of genetic algorithms. He awarded in 1961 the Louis E. Levy Medal from The Franklin Institute.

Holland was born in Fort Wayne (Indiana) in 1929. He studied Physics at the Massachusetts Institute of Technology and received a B.S. in 1950, studied Mathematics at the University of Michigan and received an M.A. in 1954. In 1959 he was the recipient of the first computer science Ph.D. from the University of Michigan. He is also a member of the Centre for the Study of Complex Systems (CSCS) at the University of Michigan, and a member of the Board of Trustees and Science Board of the Santa Fe Institute.

John H Holland is the recipient of a MacArthur Fellowship and a fellow of the World Economic Forum.

3.4 Artificial adaptive agents in complex adaptive systems

Artificial adaptive agents can be defined and tested in a variety of artificial worlds, evolving themselves in a period of time. The obtained complex adaptive systems can be evaluated both computationally and analytically, in order to obtain a good way of experimenting adaptive economic agents.

Different features characterize a complex adaptive system:

- It is created by an interacting agents network;
- It has a dynamic behaviour emerging from the agents activities;
- Its behaviour can be described without knowledge of the behaviour of the individuals interacting in the system.

An agent can be defined "adaptive" if it satisfies two criteria:

- A value can be assigned to its actions happening in the environment;
- This value increases over time thanks to the agents' actions.

A complex adaptive system, then, can be considered as a complex system in which adaptive agents act in an environment by including other agents in this system. A theory based on complex adaptive system and artificial adaptive agents makes possible the development of flexible models exhibiting emergent behaviour that can capture a range of economic phenomena.

3.4.1 The method

"Models based on pure linguistic descriptions, while infinitely flexible, often fail to be logically consistent. Mathematical models lose flexibility, but gain a consistent structure and general solution techniques. The Artificial Adaptive Agent models, specified in a computer language, retain much of the flexibility of pure linguistic models, while having precision and consistency enforced by the language. The resulting models are dynamic and are executable in the sense that unfolding behaviour of the model can be observed step by step. This makes it possible to check the

plausibility of the behaviour implied by the assumptions of the model" (from Holland (1991), p.366)

An AAA model gives the opportunity of making experiments related to utility, expectations, knowledge that can be reset at any variation of the environment conditions. One fundamental feature of this tool is the capability of showing emergent behaviours endogenously generated, that can be explored and can create new theorems.

These model typologies are also useful to investigate complex economic systems, with no easily derived analytic solutions, that have to be optimized.

In order to implement the optimal solution, there exists a wide range of computer-based adaptive algorithms, including genetic algorithm.

3.5 Netlogo

Netlogo is a programmable modelling environment used in simulating natural and social phenomena. It was authored by Uri Wilensky in 1999 and has been in continuous development ever since at the Centre for Connected Learning and Computer-Based Modelling.

It is particularly well suited for modelling complex systems developing over time. Modellers can give instructions to thousands of "agents" that operate independently. This makes it possible to explore the connection between the micro-level behaviour of individuals and the macro-level patterns that emerge from the interaction of many individuals.

It is sufficiently advanced to serve as a powerful tool for researchers in many fields.

The program has extensive documentation and tutorials. It also comes with a Models Library, which is a large collection of pre-written simulations that can be used and modified. These simulations address many content areas in the natural and social sciences, including biology and medicine, physics and chemistry, mathematics and computer science, economics and social psychology.

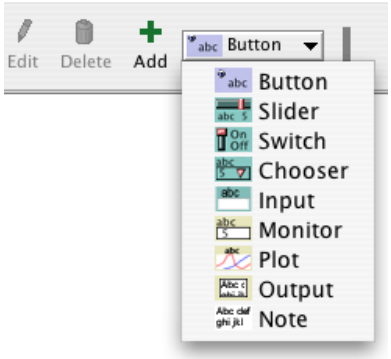
NetLogo can also enforce a classroom participatory-simulation tool called HubNet. Through the use of networked computers or handheld devices such as Texas Instruments graphing calculators, each programmer can control an agent in a simulation.

NetLogo is the next generation of the series of multi-agent modelling languages that started with StarLogo. NetLogo runs on the Java virtual machine, so it works on all major platforms (Mac, Windows, Linux).

The program structure can be resumed in three main tabs: the interface, the information and the procedure.

3.5.1 The interface tab

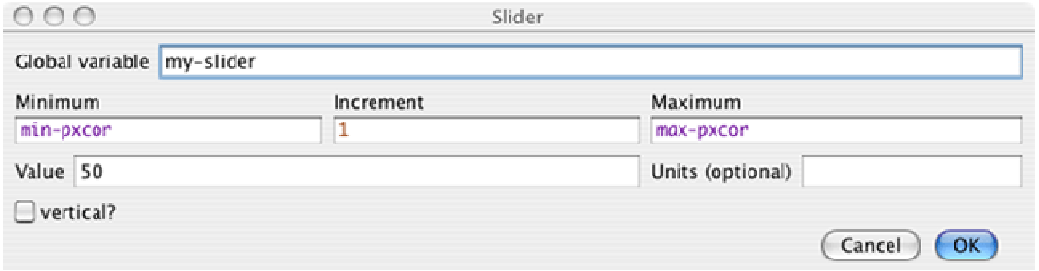
The toolbar contains buttons that let you edit, delete, and create items in the Interface tab and a menu that lets you select different interface items (showed in the picture below).



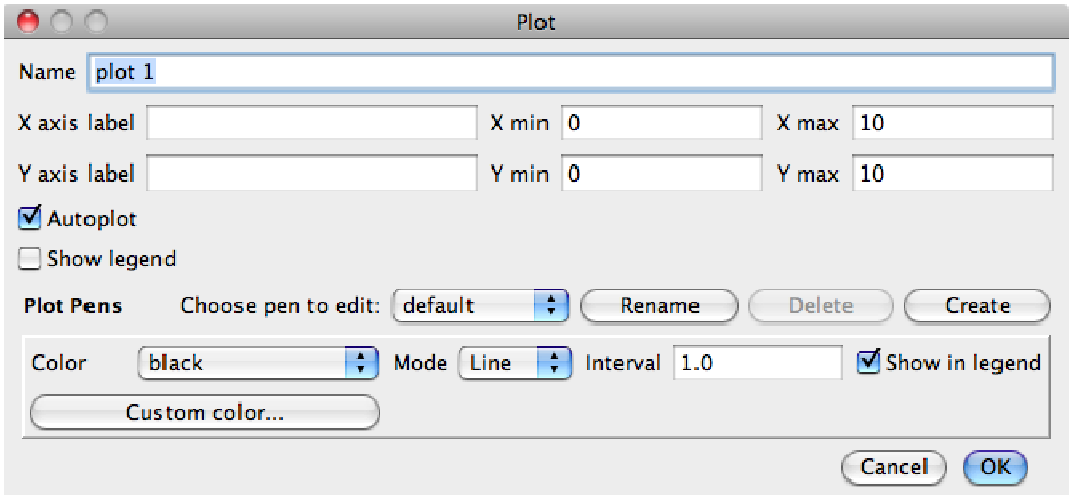
We proceed with a brief description of each instrument:

- ***Buttons***, can be either *once-only* (executing its instructions once) buttons or *forever* buttons (executing over and over, until clicking on the button again to stop the action). If you have assigned an action key to the button, pressing the corresponding keyboard key will act just like a button press when the button is in focus. Buttons with action keys have a letter in the upper right corner of the button to show what the action key is;

  It is typical to have at least two buttons, a *setup* one, with a correspondent named procedure that clears the display (Ca) and initializes the state of the model, and a *go* button to run the model;
- ***Slider,*** global variables, which are accessible by all agents. They are used in models as a quick way to change a variable without having to recode the procedure every time. The user can move the slider to a value and observe what happens in the model. The picture shows the fundamental features of the command:

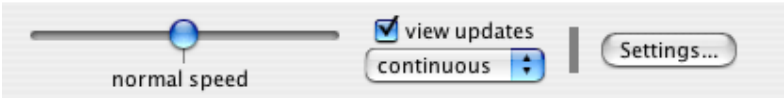


- ***Switch,*** is a visual representation for a true/false (Boolean) variable. The user is asked to set the variable to either on (true) or off (false) by flipping the switch;
- ***Chooser,*** let the user choose a value for a global variable from a list of choices, presented in a drop down menu;
- ***Input,*** global variables that contain string or numbers. The author chooses which types of values the user can enter. Input boxes can be set to check the syntax of a string for commands or reporters. Number input boxes read any type of constant number expression which allows a more open way to express numbers than a slider;
- ***Monitor,*** display the value of any expression, it could be a variable, a complex expression, or a call to a reporter. Monitors automatically update several times per second;
- ***Plots,*** real-time graphs of data that the model is generating. In the picture the fundamental issues are resumed:



Plots can be defined along with their name (which can then be referenced in the code), their axes set up, and plot pens set up. The use of these last ones is for having multiple graphs on the same set of axes. The profile (colour, mode, and interval) for the plot pen can be set here, and then that particular pen can be drawn with by first specifying which pen is to be used in the code, followed by a list of plotting commands;

- ***Output,*** a scrolling area of text that can be used to create a log of activity in the model. A model may only have one output area;
- ***Notes,*** lets you add informative text labels to the Interface tab.



Going on in the description we can mention the slider that allows controlling how fast the model runs and the features about the updates. They could be “continuous”, meaning that NetLogo redraws the view many times a second, regardless of what is going on in the model, or “tick-based” if the view only updates when the tick counter advances.

The large black square in the Interface tab is the 2D view. It's a visual representation of the NetLogo world of turtles and patches.

The 2D view has several different options that prove useful in modelling. The size of the grid (the number of cells) can be changed, as can the size of the cells themselves (in pixels). The edges of the model world can be changed to reflect the system the model has to represent; the choices here are to treat the edges as walls, or to treat them as wrapping around onto the cells on the opposite side of the grid. Initially it's all black because the patches are black and there are no turtles yet. You can also open the 3D View, another visual representation of the Netlogo world, by clicking on the "3D" button in the View Control Strip.

3.5.2 The Information tab

The Information tab provides an introduction to the model and an explanation of how to use it, things to explore, ways to extend the model, and NetLogo features.

3.5.3 The procedure tab

It is the workspace where the code for the model is stored. Commands you only want to use immediately go in the Command Center; commands you want to save and use later, over and over again, are found in the procedures tab.
To determine if in the code there are any errors, you may press the "Check" button. If there are, the Procedures tab will turn red and the code that contains the error will be highlighted and a comment will appear in the top box.

3.5.4 The Behavior Space

BehaviorSpace is a software tool integrated with NetLogo that allows you to perform experiments with models. It runs a model many times, systematically varying the model's settings and recording the results of each model run. This process, sometimes called "parameter sweeping", lets you explore the model's "space" of possible behaviours and determine which combinations of settings cause the most useful behaviours.
Models often have many settings, each of which can take a range of values. Together they define a parameter space, whose dimensions are the number of settings, and in which every point is a particular combination of values. Running a model with different settings can lead to drastically different behaviours in the system being shaped. So the program helps the model creator in discovering which particular configuration of values will yield the kind of behaviour he is interested in.

3.5.5 The Netlogo Programming procedure

Before giving details on the commands, it is necessary to define the types of agents on which they can manage. NetLogo has a number of types of agents/turtles, patches, links, and the observer agent. The observer is a single agent that has a view of the whole NetLogo “world" (turtles, links and patches), and is used for running the main parts of the program, (linked to buttons on the interface) as well as providing a way of interacting on the main interface.

The block of code that forms a procedure begins with “*to procedure-name*” on a line by itself and on the next lines comes a set of commands (primitives, or procedures or reporters), and it ends with the keyword *end.*

Breeds are a way of specifying different classes of turtles and links. These different classes can have different state variables and could behave in many different ways, by asking them to run various procedures and reporters. Breeds are specified, at the code begin, by using the breed keyword, followed by the plural and singular forms of the breed name (in that order) enclosed in square brackets.

Variables are the *loci* where information is stored. It can be distinguished among:

- ***Global Variables***, holding values that are accessible everywhere in the program;
- ***Local variables,*** holding ones accessible only within a certain block of code (something enclosed in square brackets or within a procedure or reporter). Local variables are defined using the keyword *let*. This command creates a variable, and assigns it an initial value, which must be specified;
- ***Variables owned by turtles, links, or patches***. Using the -own suffix for a type of agents or the plural form of a breed name, and then listing the variables can define these.

Netlogo features many different procedures in creating plots. If there are multiple plots and/or pens, these should be selected using the function *set-current-plot “plot name*" to select it (replacing this procedure also in the case of the plot-pen case). The plot name and pen name strings should match what has been defined in the interface. There are two primary commands for plotting points, *plot* and *plotxy*. The difference

stands on the fact that the first one uses an x-value from the last time when plot was used (for that particular plot and pen) plus some interval. The x-value starts with a value of zero for the first time plot is used for that plot and pen.

Additionally, NetLogo has a set of commands for writing output to files. To open files for reading or writing them, it can be used the *file-open* command, followed by whitespace and then the filename in double quote marks.

Lastly, even if complete description of the program commands could be impossible, we proceed in summarizing some of the most useful logic commands, through a table:

Command	Effect
if test [commands when true]	This runs a test, and then if true runs the command. The test must be some reporter that returns true or false, for example *xcor* > *0* or *who* = *3*.
ifelse test [commands when true] [commands when false]	Like the *if* command, except that this command has a section of commands (enclosed in a second pair of square brackets) to be run when the returns false.
while [reporter] [commands]	While the reporter returns true, this command runs the commands listed in the second set of square brackets. Note that one should be careful that the reporter will at some stage return false, otherwise this will loop forever (until the program is stopped manually).
foreach [list] [commands]	This applies the set of commands to every element of the list.

Table 3.1: Control Logic Commands, for changing the flow of execution of a program, 2009 (Source: M.Berryman, S. Angus)

4. The initial model

Before starting a new model more related to the reality, we have to restore our previous simulation in which our aim was trying to analyse "what does the stork bring to women's working career?" or better the motherhood effects on working women; we were interested in trying to simulate the relationship between the female gender and the career opportunities in a common firm: "The widespread increase in women's participation to the labour market over the last thirty years represents undoubtedly a relevant phenomenon for its economic and social impact. Even if female participation rate is still far from the male one, its increase made it necessary for the national and local governments to promote policies and services aimed at making work and family life compatible." (from Pacelli L., Pasqua S., Villosio C., 2008).

Particularly, we wanted to observe the possible improvement for the whole economy when agents have the possibility of exploiting not only a full-time solution but also a part-time one; we wanted also to verify evidence in favour of the usefulness of the part-time solution.

The theoretical basis of our work was the consideration that the mothers choice of working or not could determine a change in the whole labour force and the possible relationship between the level of employment and the economic growth (the whole economy was determined only by a fixed amount of capital, not relevant in terms of the analysis, and by the amount of labour in the market).

In this model, we used a simplified version representing the economic growth considering the economy as a sum of the added values generated in the market by the interactions between demand and supply.

Concerning the first one, we have considered the Italian population dynamics in last years: even if the total number of the available vacancies decreases (related to the general contraction due to the world wide economic crisis), the number of male and female subjects in work age decreases even faster. The last consideration is strictly linked with the Italian population composition: in fact, we can say that the population pyramid has, as particular feature, a high concentration of people in the age class between 30-40 years old. The young classes, instead, are not so populated.

The total effect of this interaction can be represented by a little increase on the demand side both in case of recessionary and expansionary period. Then, during the simulation, we have assumed that the actual amount of demanded labour was set exogenously by the level of the previous period multiplied by a fixed coefficient (greater than 1) related to the previous explanation. Going deeply, we divided the demand in two different categories: one searching for workers with high formation level and the other with a low one and this composition increases in relation with the whole economy condition (recession or expansion).

The description of the supply side is more complex and related with the simulation where we have decided that the agents were the employees, particularly the female ones, included in a range between 25 and 45 years old. Because the reality is too complex to be described, we have used a simplification where men, characterized by a physiological rate of employment, were not relevant; also women over 45 were not considered because, at that time, the difference of being mother or not was not relevant (indeed we assumed that the childcare was no longer a problem for the mothers career). The time variable has been expressed by the calculus cycle established on one year. At the end of each cycle, the model evolves with respect to time.

At each tick, a portion of agents has entered in the model (representing the new labour force) and another part has exited from this one (entering in the not considered categories mentioned above). The crucial point was the fact that the entering female agents were all not-mothers, whereas the exiting ones can be alternatively mothers or not (under the simplifying assumption that all women under 25 cannot be pregnant).

Moreover, thanks to the agents based simulation, each woman was carrying her information along time: at each cycle we can know the age of each agent, if she was pregnant or not and if she was employed and if she can exploit the part-time opportunity.

While the age was computed automatically, the event of being pregnant was established by the fecundity rate associated with the woman age (Banca Dati al Femminile Inail, expressed on 1000 inhabitants).

The choice between working or not was linked with several elements:

- Individual propensity to labour represented by the education level, characterizing each agent forever, independently from the path of other variables: greater the level of education, greater the propensity (well-educated women were more likely to keep on their careers even if they were pregnant);
- Availability of childcare services in the interested area;
- Availability of family members useful to look after the children.

Each woman, each cycle, has chosen between working or not by taking into account the features characterising herself and only matching the demand and the supply we can define the real amount of workers in the market.

Once defined them, we were interested in estimating the effect of the labour equilibrium produced on the whole economy (measuring itself as the sum of the added-values produced by each agent every year).

4.1 The code

Firstly, we defined the *global* variables used across the whole code, the subject typology (*breed*) iterating in the simulation and their own information.

```
globals [demand demand-in supply-uni supply-notuni supply fertility flux prop N-women prob-grans
         inc-p-uni inc-p-grans inc-p-care pbase-mother pbase-notmother year add-value]
breed [women woman]
women-own [age mother sup-comp grans c-care formation worker part-time]
```

The subject woman carries her information about: her age (between 25-45 years old), if she is mother or not, if she is a supply component in the labour market, if there is availability of grandparents and childcare services to look after the children, if she has a university formation, if she is a worker or not and, lastly, if she could exploit a part-time job.

Defining the *setup,* we have left to the observer the possibility of choosing the amount of subjects for each class of age interacting in the model, throughout a slider in the interface (fixing at 20 the age classes: 25-44 years); furthermore we have inserted the fecundity indexes, the probability of having grandparents, and then the basic probability of searching for a job (subject to different conditions: mother with or without the part-time availability, not mother) increased by a fixed additional values representing either the ownership of a university formation, of an efficient child-care service, or of a grand-parents availability. To describe the demand side, we have firstly defined its initial level, fixing exogenously its amount to the *women-per-age-class*, subtracting to this one an arbitrary 10%.

```
to setup
  ca
  set N-women women-per-age-class * 20
  set demand-in  0.90 * N-women
  set demand demand-in
  set fertility [0.0512 0.0644 0.0735 0.082 0.0888 0.0952 0.0968 0.0959
                 0.0918 0.0863 0.0779 0.0677 0.055 0.0439 0.0335 0.0245 0.0217 0.0193 0.0121 0.009]
  set prob-grans 0.5
  set inc-p-uni 0.184
  set inc-p-grans 0.06
  set inc-p-care 0.03
  ifelse part-time-availability [set pbase-mother 0.6][set pbase-mother 0.2]
  set pbase-notmother 0.75
```

Carrying on with the *setup* description, we have exploited a particular Netlogo tool: the *foreach* command, that gives us the possibility of running the action for each item of the list; in our case the last one is represented by the *n-values* command that reports a list of length size containing values computed by repeatedly running the content of the square brackets. Particularly, in our simulation, we use the *"?"* to refer to the number of the item currently being computed, starting from 0.

```
  foreach n-values (20) [?]
  [
    ask women[set age age + 1]
    create-women women-per-age-class

    [
      set age 25
      set mother false
      ifelse random-float 1 < prob-university [set formation true][set formation false]
      ifelse random-float 1 < prob-grans [set grans true][set grans false]
      ifelse random-float 1 < childcare [set c-care true][set c-care false]
      set shape "person"
      set size 1
      fd random 15
      set part-time false
        ]
    ask women [
      if not mother [if random-float 1 < item (age - 25) fertility [set mother true]] |
      let p-supcomp 0
      ifelse mother [set p-supcomp pbase-mother][set p-supcomp pbase-notmother]
      if mother [
        if formation [set p-supcomp (p-supcomp + inc-p-uni)]
        if grans [set p-supcomp (p-supcomp + inc-p-grans)]
        if c-care [set p-supcomp (p-supcomp + inc-p-care)]
      ]
      ifelse random-float 1 < p-supcomp [set sup-comp true][set sup-comp false]
      ifelse mother [set color pink] [set color green]
    ]
  ]
end
```

Within this tool, we have described the subjects entering in the simulation: we gave them a particular age (25), shape, size, movement; furthermore, we have set them such as not mother, without part-time availability. To define the other features we have established that if a random floating number between 0 and 1 is inferior to the correspondent probability value (given previously) then this characteristic will be set as true (otherwise false).

To define the condition of being mother or not, we used the same procedure of the *random float* comparing the extracted random number with the fecundity rate associated to each age class; then, we have established the pink colour for the mother subjects and the green one for not-mother ones.

Referring to the job conditions, firstly we have defined not properly the worker issue but the probability of being a supply component. At the beginning, each breed is set at 0 value, then we construct the probability of being a supply component, summing all the previously described increases. Lastly, if a random floating number is inferior to that probability value we set the breed as a supply component.

```
to go
  set year year + 1
  ask women[set age age + 1]
  set supply-uni 0
  set supply-notuni 0
  set supply 0
  create-women women-per-age-class [
      set age 25
      set mother false
      ifelse random-float 1 < prob-university [set formation true][set formation false]
      ifelse random-float 1 < prob-grans [set grans true][set grans false]
      ifelse random-float 1 < childcare [set c-care true][set c-care false]
      set shape "person"
      set color green
      set size 1
      set part-time false
   ]
  ask women [
      if age > 44 [die]
      if not mother [if random-float 1 < item (age - 25) fertility [set mother true]]
      let p-supcomp 0
      ifelse mother [set p-supcomp pbase-mother][set p-supcomp pbase-notmother]
      if mother [
        if formation [set p-supcomp (p-supcomp + inc-p-uni)]
        if grans [set p-supcomp (p-supcomp + inc-p-grans)]
        if c-care [set p-supcomp (p-supcomp + inc-p-care)]
      ]
      ifelse random-float 1 < p-supcomp [set sup-comp true][set sup-comp false]
      if sup-comp [ifelse formation [set supply-uni supply-uni + 1][set supply-notuni supply-notuni + 1]]
      ifelse mother [set color pink] [set color green]
  ]
```

Starting with the *Go* procedure, at every cycle (set as a year) the previous code part is iterated in inserting new subjects, adding some useful information.

Considering that every subject at each year is growing old, at each cycle a part of the agent will exit from the simulation (entering in the age class not interesting for our study).

Each breed that becomes, over time, a supply component implements the total amount of supply: to be more precise we divided the supply into two categories in relation with the formation level (*supply-uni, supply-notuni),* the sum of these two values figures out the whole supply level, that is set equal to 0 at the begin of the *Go* procedure.

```
set supply supply-uni + supply-notuni
ifelse expansion [set demand demand * 1.008][set demand demand * 1.002]
let p-uni 0
let p-notuni 0
let demand-uni 0.3 * demand
let demand-notuni 0.7 * demand
ifelse expansion [
 set demand-notuni demand-notuni * 1.1
 set demand-uni demand - demand-notuni
```

On the demand side, we made a distinction between expansion and recession.

This difference matters to two fields: firstly, the growth rate set exogenously at 0.08 % in case of expansion and 0.02 % otherwise and, secondly, the composition of the demand itself.

Referring to last one, we have established a general distribution of the demand (30 % of graduated workers and 70% of no-graduated workers) that varies over time towards the no-graduates subjects in case of expansion and towards the graduates' one otherwise.

```
  ifelse supply > demand [
    if supply-uni > 0 [set p-uni demand-uni / supply-uni]
    if supply-notuni > 0 [set p-notuni demand-notuni / supply-notuni]
  ]
  [
   set p-uni 1.1
   set p-notuni 1.1
  ]
 ]
 [
  set demand-uni demand-uni * 1.1
  set demand-notuni demand - demand-uni
  ifelse supply > demand [
    if supply-uni > 0 [set p-uni demand-uni / supply-uni]
    if supply-notuni > 0 [set p-notuni demand-notuni / supply-notuni]
  ]
  [
    set p-uni 1.1
    set p-notuni 1.1
  ]
 ]
 ask women[
 ifelse sup-comp [
   ifelse formation [ifelse random-float 1 < p-uni [set worker true][set worker false]]
    [[ifelse random-float 1 < p-notuni [set worker true][set worker false]]
   if part-time-availability [if worker [if mother[ifelse random-float 1 < 0.28 [set part-time true][set part-time false]]]]
 ]
 [
   set worker false
 ]
 ]
```

To picture the equilibrium on the labour market, we have made a comparison between the demand and the supply side.

If the supply is greater than the demand, this would mean that a part of the agents will remain outside the labour world: in order to define the worker subjects we have firstly made a distinction between graduated or not breeds; secondly, we have established the *p-uni and p-notuni* values as the ratios between the *demand* and the *supply* of the corresponding category. Subsequently we used the random floating tool, comparing this random number to the obtained probability, in order to define the numbers of the agent present in the labour world that have become *worker.*

In the opposite case (demand > supply), we have simply assumed that all the subjects interacting in the labour world can become workers, with the same previous procedure.

Once calculated the amount of workers in the market, we established that automatically 28 % of them would exploit the part-time condition.

```
set add-value 0
ask women
[
if worker[
  ifelse mother
  [
    ifelse formation
    [
      ifelse part-time
      [
        set add-value add-value + 12
      ]
      [
        set add-value add-value + 20
      ]
    ]
    [
      ifelse part-time
      [
        set add-value add-value + 10
      ]
      [
        set add-value add-value + 16
      ]
    ]
  ]
```

```
  [
    ifelse formation
    [
      set add-value add-value + 21
    ]
    [
      set add-value add-value + 17
    ]
  ]
]
graph
end
```

To represent the effect of the labour market equilibrium condition on the whole economy, we have decided to picture it as the sum of the added value produced by each worker in any year.

So, we have established arbitrary values correspondent to every individuated categories. Summing the added values of all the subjects operating in each given year, we can analyse the economic path, along the time, under different assumptions, making considerations about the usefulness of the part-time opportunity.

Lastly, we have positioned the breed in the interface space dividing them in three different categories: the part-time workers (that are all mothers) in the upper part of the screen; the full-time workers in the middle and, then, the not-workers subjects in the lower one.

```
to graph
  let xnw -1
  let xp -1
  let xnp -1
  let yp 30
  let ynp 20
  let ynw 8
  ask women
  [
    ifelse worker
    [
      ifelse part-time
      [
        set xp xp + 1
        if xp > max-pxcor
        [
          set xp 0
          set yp yp - 2
        ]
```

```
      set xcor xnp
      set ycor ynp
    ]
    ]
    [
      set xnw xnw + 1
      if xnw > max-pxcor [
        set xnw 0
        set ynw ynw - 2
      ]
  set xcor xnw
  set ycor ynw
]
]
```

Additionally, in order to capture the variables dynamics, we have decided to create two plots:

- One that represents the path of the economy pictured as the sum of the added values,
- The other representing the path of the demand side of the labour market, set exogenously, and the supply side as a result of the agents' interaction process.

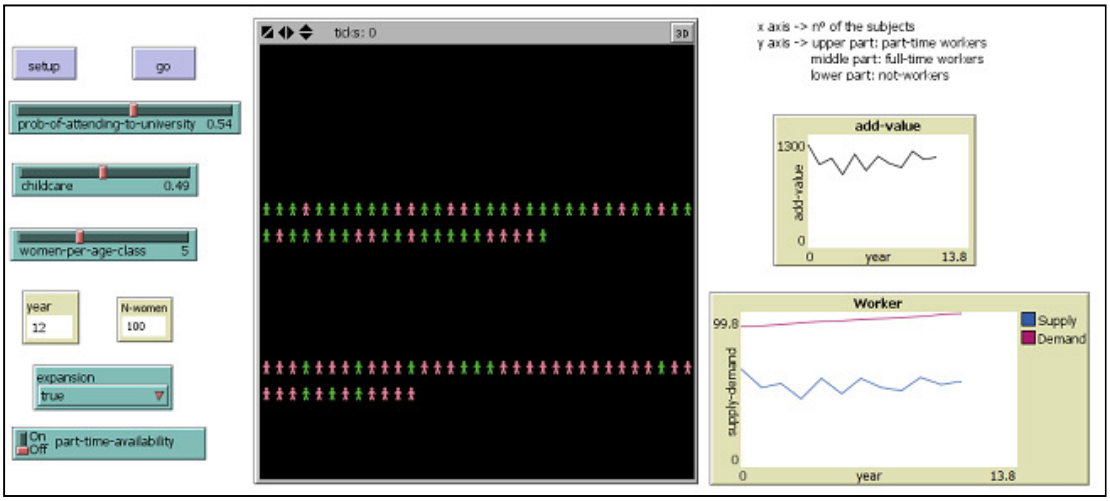
```
  set-current-plot "add-value"
  set-current-plot-pen "add-value"
  plot add-value

  set-current-plot "Worker"
  set-current-plot-pen "Supply"
  plot int (supply)

  set-current-plot "Worker"
  set-current-plot-pen "Demand"
  plot demand


end
```

4.2 The observations

Observation 1. Firstly, we have defined the case of an expansionary condition of our economy, in which firms offer only full-time contracts. Describing the general set used in this observation, we have an intermediate level of formation and child-care services availability.

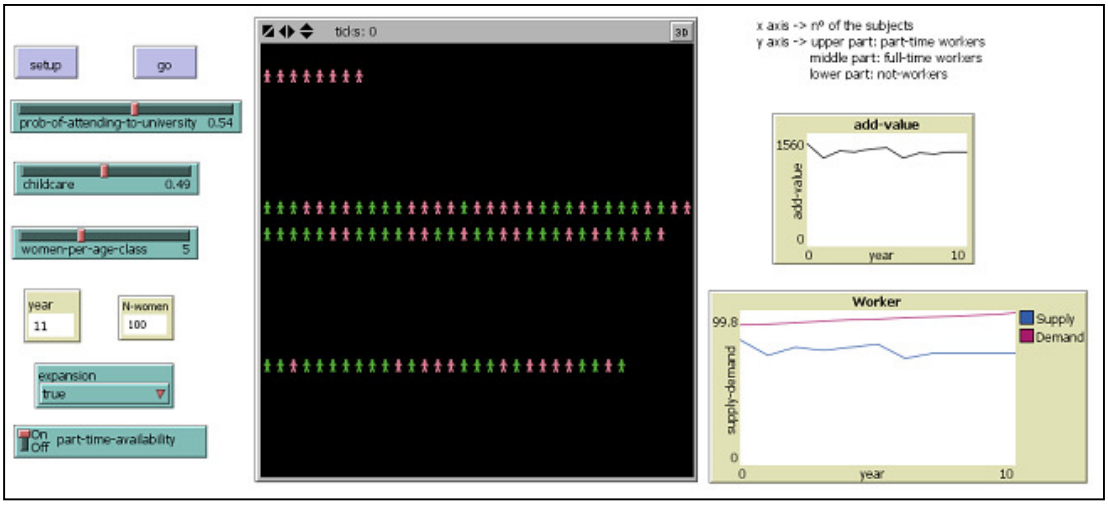
As the picture demonstrates, no subjects can exploit the part-time solution. Related to the fact that the demand along the path is always above the supply, all subjects that want to work have the possibility of doing this; it also implies that the subjects pertaining to the lower part of the picture are voluntary outside the labour market (underlined by the great presence in this category of pink mothers' subjects).

Evaluating the added value created by the economy we can say that the range is roughly around the value of 1300.



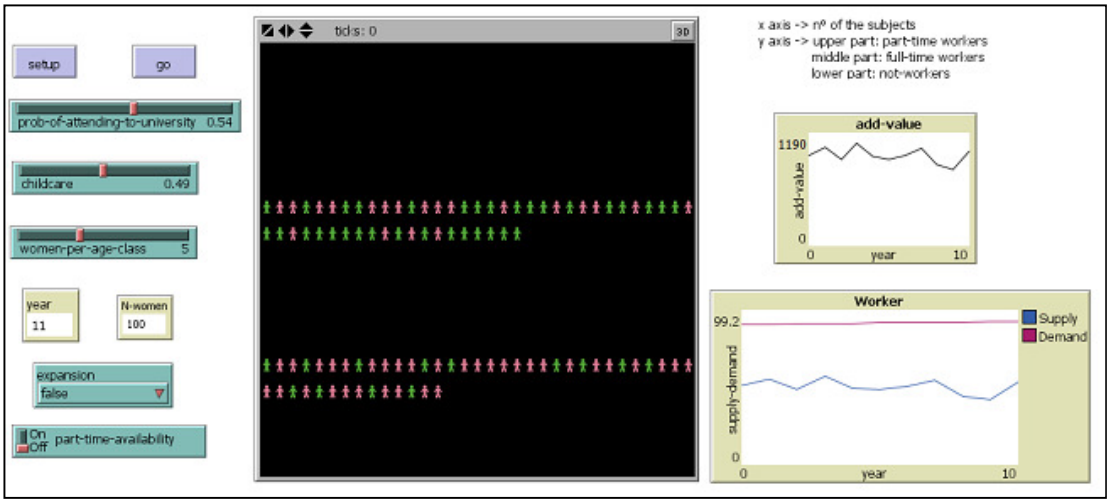
Observation 2. Secondly, we have defined the expansionary case but under the possibility of exploiting a part-time condition. The other set-up variables remain the same.

Even if also in this case the demand side stays always above the supply along the path, the composition of the labour market is changed a lot: the number of not-worker is inferior than before thanks to the fact that a consistent part of the previous not-worker has become a worker, exploiting the part-time condition. The most interesting consideration can be driven by the evaluation of the added value path: in this case is increased a lot, attested around the value of 1560.



By the comparison between the two results, we can say that the part-time condition is fundamental in augmenting the total value produced on the market. It is also important to say that every estimates of the added value can be considered as an underestimation due to the fact that, in the reality, each time that a mother chooses to remain in the labour world, in order to work, she has to sustain a cost, that, if evaluated on the whole economy, corresponds to an additional boost in the added-value: substantially, to allows mothers working, other subjects (not necessarily women ones) have to work to provide her services (such as nursery and school teachers).

Observation 3. Thirdly, we have pictured the case of a recession period, without the possibility of exploiting a part-time opportunity (also in this case the general set-up remains the same). As in the case of expansion, we can see a large amount of not workers, particularly mothers, that, voluntary, decides to stay out of the labour market. Concerning the demand and supply path, it can be noted that the demand, even if always attested on a higher level than the supply, has a fundamental difference feature in comparison with the expansion case: its slope is inferior, due to an annual increment inferior in its value, as expressed by the recession condition. In the context described, there is a creation of an added value roughly of 1190, a lower one with respect to what we have described in the *Observation n.1 (*further evidence in favour of the recession presence).

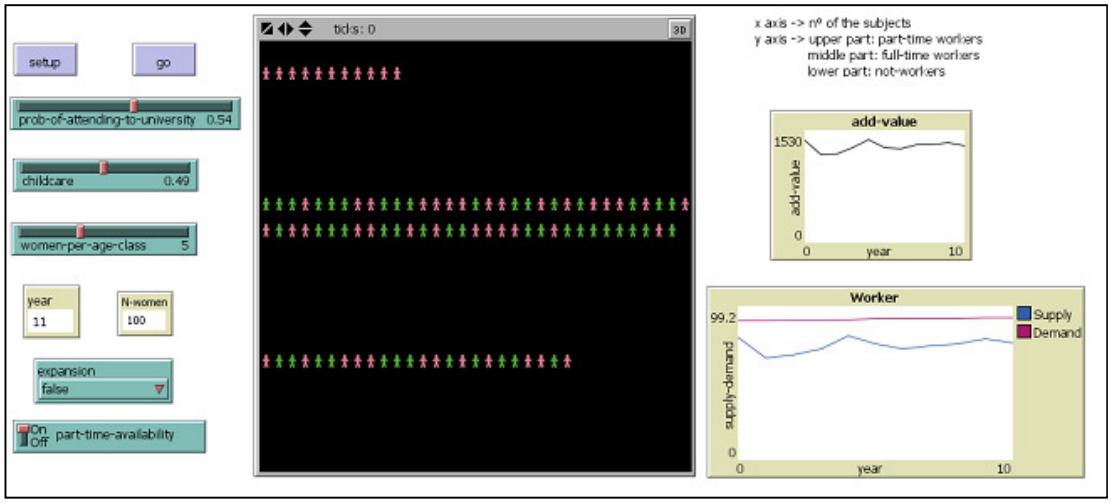


Observation 4. Fourthly, we have considered the case of recession under the availability of part-time (the initial set-up for other information remains constant).

In this case the amount of not-workers is reduced a lot, with a migratory tendency of the subjects from this category to the part-time one. There could be interesting also underlining that the amount of the mother part-time workers represents roughly the percentage of workers that in the real context would use the part-time solution (*circiter* 28% of the total workers amount).

On the demand-supply side, we see the same previous conditions: a demand with an inferior slope and always above the supply path.

Lastly, considering the amount of added value produced on time we can see a consistent improve in this level that is around a 1530 value.

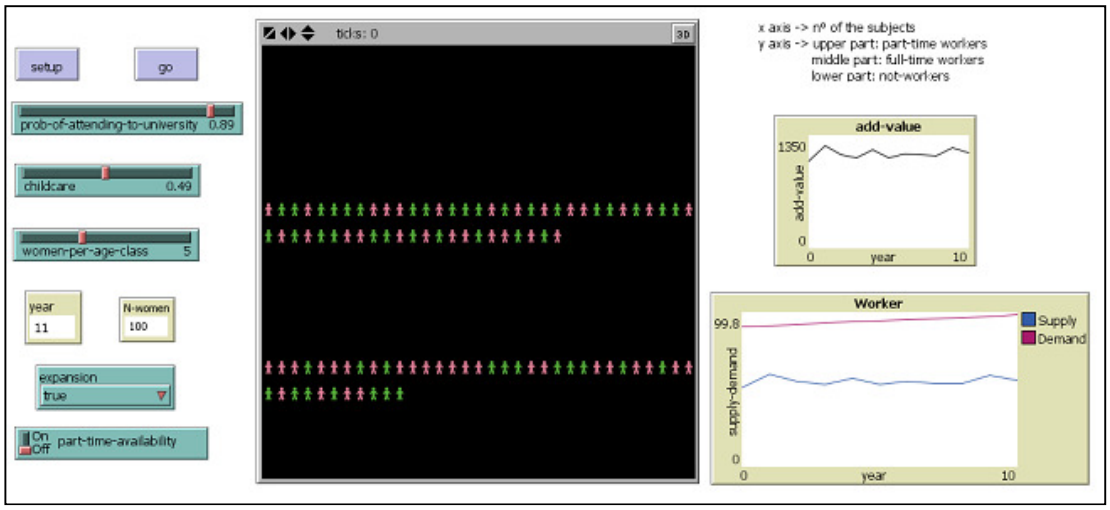


Also in the recession case, the interaction of the subjects provides evidence on the usefulness of the part-time availability in increasing the presence of mothers on the labour market, and in augmenting the total value produced. Further, comparing the case of recession and expansion, we can underline the increase in value in the positive case, even if (starting from the assumption that the whole economy is suffering) this increase cannot be considered really consistent.

Observation 5. To verify the meaningfulness of the variables introduced in the simulation, we have verified different hypothesis related to different values of the most important model variables.

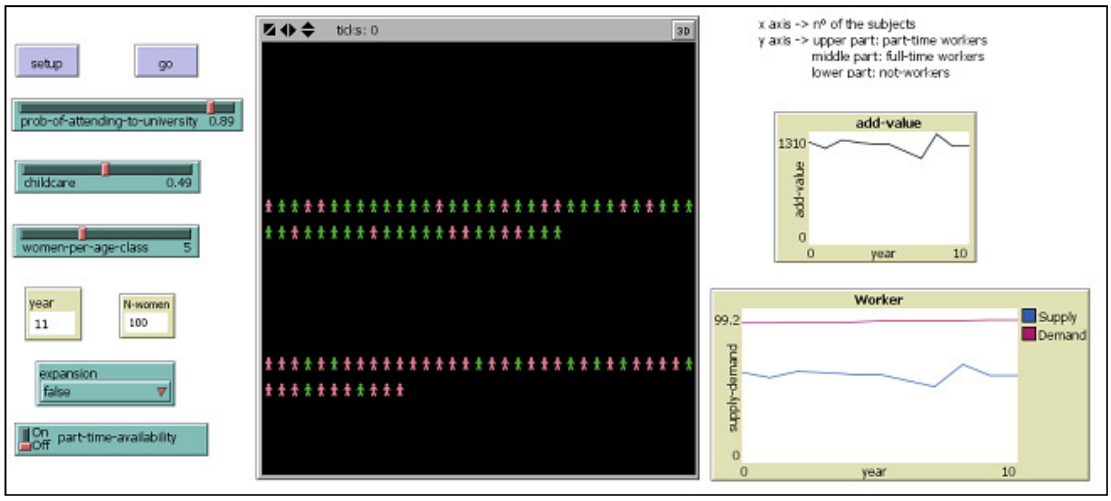
Particularly, we have chosen to set the level of formation on an excessive one (the data have not to be considered as real, but an extreme one) in order to capture the results in a clearest way.

With a high level of formation, we can see that, generally, in comparison with the previous analysed cases, there is an improvement in the level of added value produced. At the same time we note that this augment is much more considerable in a recession case rather than in an expansionary one. This could due to the features of the labour market: there is a general composition of it, making a distinction between subjects with or without a great level of formation that, subject to a particular path of the economy, increases.



On one side, during a recession, the demand for worker should be concentrated on the agents with more education (in order to searching for new growth possibilities on the market); on the other side, during an expansionary period, the demand should be more interested in subjects with a lower level of formation, but also with lower claims on the salary; this can represent an opportunity of reducing costs in order to remain competitive in a growing market.

Also the contrary could be verified: in correspondence with a lower level of formation, there is a general decrease in the added value produced and the most significant is registered during an expansionary period.



5. Our simulation model

With the aim of improving the previous inserted model, we want rephrased it in a more detailed version, which will allow us to feature deeply the agents, in order to better catch the relationships arising between the variables taken into consideration.

5.1 The dataset

In searching for the dataset that have to be used in our analysis, we have referred mainly to the LABORatorio Riccardo Revelli, sponsored by the University of Turin. Bruno Contini directs it and it represents a research institute within Collegio Carlo Alberto. It was created at the beginning of 1999 from the cooperation between the University of Turin and the Compagnia di San Paolo.

The LABORatorio conducts researches, jointly with researchers from national and foreign Universities and Research Centres, on various labour-related issues in Italy and in the European Union. Projects have been carried out in the following areas: labour market flexibility and mobility, costs, economic and social consequences of the new flexibility, new forms of atypical labour, wage distribution and wage mobility, analysis and evaluation methods of employment and social politics, construction of agent-based simulation models for the labour market and industrial demography studies.

Particularly, we have used Whip (Work Histories Italian Panel), a database containing individual work histories, based on Inps (National Institute of Social Security) administrative archives obtained thanks to an agreement signed between Inps and University of Turin. The reference population is given by all the Italian and foreign people who have worked in Italy even for only a part of their working career. A large representative sample has been extracted from this population: in the standard file (the one we used) the sampling coefficient is about 1: 180, for a dynamic population of about 370,000 people.

For each of these people, the main episodes of working career are observed. The complete list of observations (that we used only partially) includes: private employee working contracts, atypical contracts, self-employment activities (for instance, artisan, trader, freelancer, retirement spells, as well as non-working spells in which the individual received social benefits, like unemployment subsidies or mobility benefits). The workers whose activity is not observed in WHIP are those who worked in the public sector or as particular categories of freelancers (lawyers or notaries) having an autonomous security fund.

The WHIP section concerning employee contracts is a Linked Employer-Employee Database: in addition to the data about the contracts, thanks to a linkage with the Inps Firm Observatory, data concerning the firm (where the worker is employed) are also available.

The observed period goes from 1985 to 2004.

WHIP building procedure may be seen as a block of programs (about a hundred) that carry out four kinds of fundamental operations in a completely automatic way:

1. The normalization, cleaning and re-codification of most variables contained in the source archives;
2. Firm longitudinal identification that is fundamental to have reliable firm data (and consequently to identifying labour contracts);
3. Working contracts longitudinal identification;
4. Strengthening of the contribution record in the annual data of working contracts.

Additionally, there is also a section named metadata, the 'data about data', containing a description of all archives and variables which compose WHIP. The description includes the official name and label assigned to the variables; when the data are not self-explanatory or exhaustive, a more detailed description is included, as well as the codes used. Moreover, there is a brief explanation of the quality of the data, and when there are missing values or corrections there is a table quantifying the missing values and/or the corrections required.

We rely upon two fundamental sets: the individual file and the job spells one.

5.1.1 The individual_file

The archive contains a record for each person and the key that connects this archive with all the other ones is the id_individual. In it we can find the following variables:

- **Birth_year**, indicates the year of birth;
- **Birth_area**, displays the employee geographical area of birth if he/she is Italian, otherwise the country of birth is expressed;

Key	Value
1	North-West
2	North-East
3	Centre
4	South
5	Islands
7	Foreign Country
-9	Missing

- **Gender**, coded in this way:

Key	Value
F	Woman
M	Man
-9	Missing

- **Id_individual**, a personal identification code.

5.1.2 The job_yearly

The archives contain annual job information. Each job_yearly archive contains, for all the individuals, a record for each job activity during the year. A job is defined as a stable economic relationship between the same person and the same firm. The most recent job characteristic is listed in the archive, so if a characteristic changed during the course of the year (like the skill level or the area of work), the last characteristic is listed.

The included variables are:

- **Cont_rebate** (contribution rebate), indicating the type of contribution rebate eventually applied to the worker's contract;

Key	Value
1	No rebates
2	Training on the job contract
3	Re-employment subsidy
4	Temporary agency work
5	Others
6	Apprenticeship
-9	Missing

- **Work_days**, number of paid working days equivalent to full time. A day is considered paid when the employer paid compensation subject to tax. A week or month is considered paid if they contain at least one paid day. Conventionally, Inps reports paid days based on a 6-day working week. The conversion, justified by insurance specifications, implying that one month and one year completely “paid” are 26 weeks and 312 days respectively. In the case of part-time work, paid days and weeks are converted into days and weeks equivalent to full time;

- **Firm_area** (firm area), geographical area where the headquarter of the firm is legally based;

Key	Value
1	North-West
2	North-East
3	Centre
4	South
5	Islands
-9	Missing

- **Work_area** (area of work) indicates the Italian geographical area where the employment was performed. During the whole period of employment the employee can modify the geographical location in which he/she works;

Key	Value
1	North-West
2	North-East
3	Centre
4	South
5	Islands
6	EE
-9	Missing

- **Cig** (wage supplementary fund), flag signalling whether the employee has received a wage supplement for temporary layoffs (Cassa Integrazione Guadagni, CIG);

Key	Value
0	No
1	Yes
-9	Missing

- **Firm_size_class**, indicates the average number, ranked in classes, of employees employed by the firm during the year;

Key	Value
1	0-9
2	10-19
3	20-199
4	200-999
5	>=1000
-9	Missing

- **Job_end,** date of ending of the job spell. The variable is right censored at 31 December 1999;
- **Id_job,** links together the archives jobs and jobs_yearly;
- **Job_start**, starting date of the job spell. It is inferred from the contributions paid monthly by the employee. The variable is left censored at 1th January 1985;

- **Illness**, flag signalling whether in the year of competence the worker received an illness benefit;

Key	Value
0	No
1	Yes
-9	Missing

- **Maternity**, flag signalling whether in the reference year the worker received a pregnancy or maternity benefit;

Key	Value
0	No
1	Yes
-9	Missing

- **Ptime**, flag that indicates a part-time job;

Key	Value
0	Full-time
1	Part-time
-9	Missing

- **Compensation**, total annual compensation in euro (top coded at 1.100 euro, applied to the average weekly compensation). At the fiscal/accounting level, it represents the base for calculating social security and insurance contributions paid by the firm, the social burden of the employee and the eventual tax relief

applied to employment. Therefore, it represents the annual net compensation received by the employee, net of the social security and health benefit contributions paid by the firm but gross of the social security and health benefit contributions that have to be paid by the employee;

- **Skill**, distinguishes between various employment positions. The position of Cadre is distinguishable from that of White Collar Worker only since 1997 on;

Key	Value
1	Apprentice
2	Blue-collar
3	White-collar
4	Cadre
5	Manager
-9	Missing

- **Actual_weeks**, number of paid weeks equivalent to full time work;
- **Tfr_fund**, indicates the amount accrued by the employee in the end-of-service fund (Trattamento di Fine Rapporto, TFR). The sum is in euro;
- **Compensation** indicates the total annual compensation in euro (top coded at 1.100 euro, applied to the average weekly compensation). At the fiscal/accounting level it represents the base for calculating social security and insurance contributions paid by the firm, the social burden of the employee and the eventual tax relief applied to employment. Therefore, it represents the annual net compensation received by the employee, net of the social security and health benefit contributions paid by the firm but gross of the social security and health benefit contributions that have to be paid by the employee;
- **Sector_18**, classification of economic activity into 18 sections according to the Ateco91 classification.

Key	Value
A	Agriculture, hunting and forestry
B	Fishing
C	Mining and quarrying
D	Manufacturing
E	Electricity, gas and water supply
F	Construction
G	Commerce
H	Hotels and restaurant
I	Transport and communications
J	Financial intermediation
K	Business services
L	Public administration and defence, compulsory social security
M	Education
N	Health and social work
O	Other community, social and personal service activities
P	Activities of households
Q	Extra territorial organizations and bodies
-9	Missing

5.2 Our dataset

Once having described the whole dataset available at LABORatorio Revelli, we have to look at the new dataset that we created and used in the initial part of our Netlogo simulation.

The first step for the creation of our personalized dataset consists in joining the file containing the individual data (id_individual) with the one containing the all information related to a precise year (job_yearly) in which the specific labour data are reported.

In doing this, we have preferred using as starting point of the simulation the more recent data pool available. In particular, we have used the data of year 2004. Due to the fact that not all individual of the first dataset have a correspondent presence in the second one, we have proceeded joining, through intersection, the two datasets in order to obtain a unique one containing only those individuals appearing in both files and to remove all the others, not relevant in our analysis and not useful for our simulation. We have computed this procedure by using Excel, available at Microsoft Office. Once obtained this unique dataset, we have removed those columns containing variables not relevant for our analysis, in order to leave only ones useful for the simulation, such as id_individual, ptime, skill, work_day, maternity, work_area, birth_area, birth_year and gender. Due to the fact that we want to take into account only the female subjects, we have ordered all individuals with their relative information with respect to the gender column obtaining, in this way, in the upper part of the file, only women (indicated by letter F). At this point, we have removed the below male part of the dataset (indicated by letter M) obtaining a new file containing only female individuals and we have deleted the gender column, now absolutely superfluous.

Once having this sample, we want to restrict it by considering only women between 20-44 years old: we have chosen this by taking into account that this is the more significant range in terms of fertility and choices related to the maternity event. To do this, we have ordered women by age and we have removed all of them out of the established range.

The second step, starting from our “only women between 20-45 years old” dataset, consists in the creation of a further random sample of only 1000 of them in order to simplify our analysis and to allow it to be read by Netlogo. This is possible by using a particular function, the *random* one, available in Excel, allowing creating a column of only random numbers that, if ordered from the lowest to the highest, mixes together our female set. At this point, we have cut the entire mixed amount of women from the thousandth position onward to obtain our new more workable dataset and we have re-introduced a column indicating a progressive id (going from 1 to 1000) to each woman.

After the women dataset creation, called *datasetLABOR*, we have created a new set, the *datasetrenawalLABOR*, containing only women between 19-20 years old, useful for the renewal process in the *Go* procedure of our simulation. In this case, we have followed the same previous procedure, but considering only women included in this age range by implying that they are the new work force entering in the market, substituting the exiting “over 44” years old women. Considering the fact that all the subjects, at the entrance moment, have the same age we have preferred, for computational reasons, to set the age of all the agents to 20 years old, removing from the dataset the column birth_year, now useless. Another difference with respect to the creation of the previous dataset is that we have not added the fictitious id counter column because in this case it is no more useful.

After these changes, we can effectively work on our datasets, proceeding with the Netlogo simulation that reads and runs them to give our agents all necessary information.

5.3 The code

In approaching the comment of the model code we decided to proceed, first of all, along the procedure (considering setup, graph and go) and, only after, through the analysis of the fundamental features of the interface, such as we did in the previous model.

5.3.1 To Setup

At the beginning of our code, as done in our previous model, we have defined the *global* variables used across the whole code, the subjects, called *breed* iterating in the simulation and their own information.

```
globals [num year fertility nmean-children reenteringunemployed cumulative_aggregate_income_North
         cumulative_aggregate_income_Centre cumulative_aggregate_income_South yearly_total_aggregate_income_South
         yearly_total_aggregate_income_North yearly_total_aggregate_income_Centre total_national_aggregate_income]

breed [women woman]

breed [firms firm]

women-own [ptime skill work_day maternity work_area birth_area birth_year mother worker neomother age ptimeworker
           grandparents c-care low-formation medium-formation high-formation onlypart-timedisposable
           delay-return compensationP compensationF compensationU]

firms-own [nwomen nfull-timeworker nunemployed nptimeworker nfulltimedemand nparttimedemand aggregate_income ]
```

First of all, we proceed defining the global variables:

- ***Num***, that corresponds to the total amount of women interacting in the model (in our case, it is equal to 1000 as the original sample size);
- ***Year***, representing the considered year;
- ***Fertility***, variable taken from ISTAT statistics, representing the probability of having a child in a particular year of age;
- ***Nmean-children***, capturing the mean number of children of a woman in a particular age class;
- ***Reenteringunemployed***, measuring the percentage of unemployed women that try to re-enter in the market, after a period of unemployment condition;

- ***Yearly_total_aggregate_income_North/Centre/South***, that corresponds to the yearly sum of the income perceived by any agent (both for part-time and full-time condition) in each Italian area;
- ***Cumulative_aggregate_income_North/Centre/South***, representing the cumulative amount of the income for each Italian area, obtained from adding the income values of all the previous years to the current year amount.
- ***Total_national_aggregate_income***, corresponding to the sum of the previous values of all the Italian areas concerned with the simulation. It could be interpreted as a sort of measure of the gross domestic richness in the Country.

In this model we inserted two different breeds: women, as in our old model, and firms. The first ones, included between 20-44 years old (the reason why is mentioned in the dataset chapter), hold all the information of the dataset previously created.

As before, each agent has a series of information coming from our dataset that he will run during the simulation procedure:

- ***Ptime***, a dummy variable, representing the possibility of working only part-time;
- ***Skill***, tracing the knowledge level of each individual;
- ***Work_day***, reporting the number of worked days a year;
- ***Maternity***, individuating the event of maternity in the year of competence;
- ***Work_area***, showing the work area;
- ***Birth_area***, showing the birth area;
- ***Birth_year***; reporting the year of birth for each subject;

  Further, we have added variables functional in the code implementation:
- ***Mother***, in order to define the condition of being mother;
- ***Neomother***, reporting the condition of having become mother in a particular year;
- ***Worker*** and ***ptimeworker***, to report the condition of the women in the labour market;
- ***Age***, obtained as the difference between the actual year and the birth year;
- ***Grandparents***, to underline the availability of grandparent for each subject considered;

- ***C-care***, that traces out the availability for each subject of relying upon the formal child-care services;
- ***Formation (high/medium/low),*** derives the information from the variable called skill; it briefly defines the competences of each agent;
- ***Delay-return***, representing an instrumental variable to trace the years that a woman can live in a particular situation (such as unemployment, or part-time);
- ***Compensation F/P/U***, reporting a mean representative yearly wage for each of the worker categories (Full-time, Part-time, unemployed). The data have been found in the Istat tables reporting the mean annual wages in Italy.

Referring to the firms, we preferred to insert only three representative agents, corresponding to the northern/central/southern mean firms. Each of these is defined by its variables:

- ***Nwomen***, counting the total number of subjects operating in that area (independently from their working condition);
- ***Nfull-timeworker/nptimeworker/nunemployed***, to divide the previous number in three different categories, related to the correspondent working condition;
- ***Nfulltimedemand/nparttimedemand***, representing the number of work positions (divided in the two corresponding categories) offered in the labour market by each representative firms. In order to be more linked to the real situation pictured by the dataset, we have decided to create a perfect correspondence between this value and the set-up level of work opportunities;
- ***Aggregate_income***, the total level of income of each area firm, defined by the sum of the compensations of each agent working in the corresponding area;

After this introductive part, we start with the *Setup* definition.

```
to setup
  ca
  set year 2004
  set cumlative_aggregate_income_North 0
  set cumlative_aggregate_income_Centre 0
  set cumlative_aggregate_income_South 0
  set total_national_aggregate_income 0

  set num 1000
  set reenteringunemployed 0.2
  set fertility [ 0.056 0.065 0.074 0.084 0.09 0.095 0.098 0.095 0.09 0.082 0.072 0.063 0.05 0.039 0.03
                  0.021 0.013 0.008 0.004 0.002 0.02 0.025 0.032 0.039 0.046]
  let i 0
  let j 0
  set nmean-children []
  while [i < 25]
  [
   set nmean-children  put 0 nmean-children
    set j 0
    while [j <= i]
    [
     set nmean-children replace-item i nmean-children ((item i nmean-children) + (item j fertility))
     set j j + 1
    ]
    set i i + 1
  ]
```

The first thing that has to be done to define the *Setup* is clearing all (*ca*), defining the starting year of the simulation (2004) and setting some variables (cumulative_aggregate_income_North/Centre/South) at 0 value.

Once defined both the number of women interacting in the model (through the *num* instrument) and the percentage of subjects desiring to try to re-enter in the labour market (after being excluded from this one for some periods) and the fertility rate for each mother year considered, we can proceed to use a fictitious way to determine the condition of being mother at the first stage of the model; particularly we want to establish a way to capture the maternity event before of the beginning of our simulation (2004). In order to do this, we defined the probability of having a child for each woman, *nmeanchildren*, at the beginning of the simulation (considering also the fact that this is not an available information in the dataset). It has also to be underlined that, we calculated them only to make our model more complete, basing the calculation on the simplifying assumption that women have at least one child. In order to define arithmetically the variable, we have added, to each yearly fertility rate, the fertility rates of all previous years.

Then, we created women to whom we give a particular size and shape, useful to the interface layout.

```
create-women num
[ set size 0.7
  set shape "person"
]

file-open "datasetLABOR.txt"

set i 0
while [i < num]
  [ask woman (file-read - 1)
    [
     set ptime file-read
     set skill file-read
     set work_day file-read
     set maternity file-read
     set work_area file-read - 1
     set birth_area file-read
     set birth_year file-read ]
  set i (i + 1)  ]

file-close
```

In order to give the useful information to each woman we inserted the *open-file* procedure to catch the data coming from our dataset; Netlogo reads the data, line by line, giving each woman the appropriate information.

At the end of this stage, we have to close the file, opened before, with *file-close,* in order to stop the reading procedure.

```
ask women
 [
  set age (year - birth_year)
  ifelse (work_day > 200) [set worker true][set worker false]
  ifelse ptime = 1 and worker [set ptimeworker true][set ptimeworker false]
  ifelse random-float 1 < informal-childcare [set grandparents true] [set grandparents false]
  ifelse random-float 1 < childcare-coverage[set c-care true] [set c-care false]
  if skill <= 2 [set low-formation true ]
  if skill > 2 [set medium-formation true]
  if skill = 3 [set high-formation true]
  if-else random-float 1 < (exp (- (item (age - 20) mean-children))) [set mother false] [set mother true]
  ifelse mother [set color pink][set color green]
  set delay-return -1
  if maternity = 1 [
    set mother true
    set neomother true
    set color violet
    if (ptimeworker) [set delay-return 3]
  ]
 ]
```

After the agents creation, we want to characterise them: in particular, we defined their age calculus, the condition of worker if the amount of worked days is greater than 200, the feature of being neo-mother and part-timer if the text file shows value 1 (remembering that, being a dummy variable, this value represents the fact that the

event has taken place) with their relative colours and the education levels (always referring to the dataset values).

In order to define both formal and informal childcare availability, we establish that if a random floating number included between 0 and 1 is inferior to the correspondent probability value of having the availability of both formal and informal childcare (defined through a slider), the related characteristic (c-care and grandparents) will be set as true (otherwise false).

Once defined the relationship between education and skills, we adopted a similar procedure in the mother condition definition: during this particular step of the code, a particular statistical distribution is hidden. We are implementing the Poisson distribution, a discrete distribution that expresses the probability of a number of events occurring in a fixed period of time if these events occur with a known average rate independently of the time since the last event.

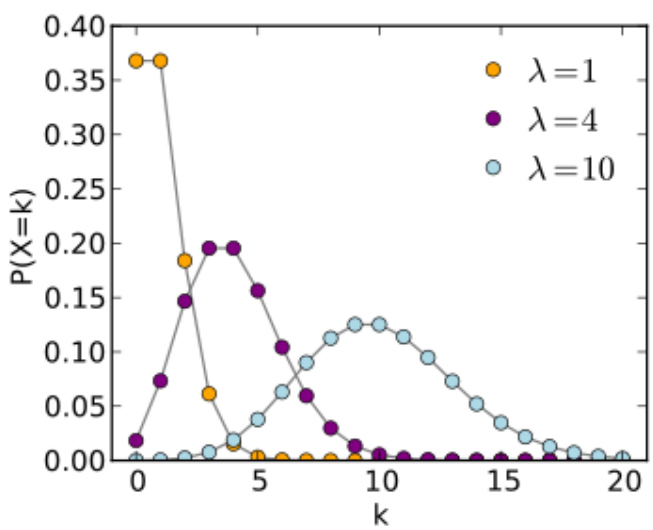


Figure .1: Example Poisson distributions with different means

If the expected number of occurrences in this interval is λ, then the probability that there are exactly k occurrences (k being a non-negative integer number), the distribution can be described by:

$$\sum_{k=0}^{x} \frac{e^{-\lambda} \lambda^{k}}{k!}$$

Where

- *E* is the base of the natural logarithm (*e*= 2.71828...);
- *K* is the number of occurrences of an event, the probability of which is given by the function;
- *k*! is the factorial of *k;*
- *λ* is a positive real number, equal to the expected number of occurrences during the given interval.

We applied, to implement it, the previously created *nmeanchildren* to a particular formula coming from the previous cited distribution.

Making a step forward, we set, for all women, a delay-return of -1. To be clearer, once defined the condition of mother and neo-mother as true, we have additionally set a delay-return to 3 (more details about this procedure will follow in the comment) on the event of maternity in the competence year.

Once defined the worker condition, we inserted the compensation level corresponding to each available category.

Additionally, we created the other breed interacting in the model: the firms.

```
create-firms 1
[
  set shape "house"
  set size 4
  set color blue
  set nfull-timeworker 0
  set nunemployed 0
  set nptimeworker 0
  set nfulltimedemand 0
  set nparttimedemand 0
  set aggregate_income 0
]
create-firms 1
[
  set shape "house"
  set size 4
  set color red
  set nfull-timeworker 0
  set nunemployed 0
  set nptimeworker 0
  set nfulltimedemand 0
  set nparttimedemand 0
  set aggregate_income 0
]
```

```
create-firms 1
[
  set shape "house"
  set size 4
  set color yellow
  set nfull-timeworker 0
  set nunemployed 0
  set nptimeworker 0
  set nfulltimedemand 0
  set nparttimedemand 0
  set aggregate_income 0
]
```

We generated three firms giving each of them the same attributes (shape, size), by setting at 0 all their own variables (the number of workers, part-timers and

unemployed, the *nfulltime* demand, *nparttime* demand and the aggregate income level). The only difference that can be analyzed is the colour, defined blue for the northern area, red for the central and yellow for the southern one.

Once defined the firms, we are interested in the creation of a sort of correspondence between women and the pertaining firms: practically, we want to locate each woman in the correspondent living/working area. At this point, we defined, for each firm, the women amount in each category, deriving from it also the level of both part-time and fulltime demand we will consider as a representative benchmark of the real situation in the labour market.

To do this, we asked women of increasing the firm population considering the fact that they can be workers, part-timers or unemployed such that they become a component of the firm of a specific area, due to the available information in the dataset.

Starting from this configuration, we inserted, in the subsequent line code, the possibility of increasing the part-time availability, multiplying the previously obtained value of part-time demand for a number, called part-time availability, having values included between 1 (in case of no increase in it) and 2 (in case of 100% increase), controlled through a slider in the interface.

```
ask women [
  ask firm (num + work_area) [set nwomen nwomen + 1]
  ifelse worker
    [ ifelse ptimeworker [ask firm (num + work_area)[
      set nptimeworker (nptimeworker + 1)
      set nparttimedemand nparttimedemand + 1
    ]
    ]

    [ask firm (num + work_area)
      [
        set nfull-timeworker nfull-timeworker + 1
        set nfulltimedemand nfulltimedemand + 1
      ]
    ]
    ]

    [ask firm (num + work area) [set nunemployed nunemployed + 1]]
let id who
ifelse worker [ifelse ptimeworker [ set compensationP 13][set compensationF 25]][set compensationU 0]
ifelse worker
     [ifelse ptimeworker
       [ask firm (num + work_area) [set aggregate_income  aggregate_income + [compensationP] of woman id]]
       [ask firm (num + work_area)  [set aggregate_income aggregate_income + [compensationF] of woman id]]]
     [ask firm (num + work_area) [set aggregate_income aggregate_income + [compensationU] of woman id]]
-
-

file-open "datasetrenewalLABOR.txt"
```

In order to define a measure for the aggregate richness produced each year by the economy of our model, we inserted a variable, called, *compensation*, representing the

mean annual wage for each category. Even if in the original dataset the compensation for each agent were available, we preferred to substitute them with a more representative and homogenous value for all the subjects; additionally, it is necessary to underline that the correspondence between part-time and full-time remuneration is not given by a perfect half amount due to the fact that, in relative terms, a part-time worker will be paid more than half of a full-time one (taking into account some particular fixed costs, such as insurance coverage and retirement incentives).

From the computational point of view, we inserted the command *id who,* that is a built-in turtle variable, holding the ID (identification) number of each agent (integer, greater or equal to 0 number), such as a variable that cannot be changed during the simulation.

We added the corresponding values for each category and, particularly, we gave the unemployed a value equal to 0, the full-time worker a value of 25 (that correspond to thousands of euro) and the part-time ones a value of 13. In order to capture an aggregate level of the produced wealth in a year, we constructed the variable *aggregate_income* of each firm as the sum of the remunerations of all women living/working in a specific area (notice that, computationally, this takes place thanks to the command *[compensation*] of woman id*).

```
  ask firms [set nparttimedemand nparttimedemand * total-parttime-availability]
  set yearly_total_aggregate_income_North [aggregate_income] of firm (num)
  set yearly_total_aggregate_income_Centre [aggregate_income] of firm (num + 1)
  set yearly_total_aggregate_income_South [aggregate_income] of firm (num + 2)

  set cumulative_aggregate_income_North cumulative_aggregate_income_North + yearly_total_aggregate_income_North
  set cumulative_aggregate_income_Centre cumulative_aggregate_income_Centre + yearly_total_aggregate_income_Centre
  set cumulative_aggregate_income_South cumulative_aggregate_income_South + yearly_total_aggregate_income_South

  set total_national_aggregate_income cumulative_aggregate_income_North
                                    + cumulative_aggregate_income_Centre
                                    + cumulative_aggregate_income_South
  graph

end
```

Lastly, only for practical reasons, we defined a global variable *yearly_total_aggregate_income* (North/Centre/South) perfectly corresponding to the value of the aggregate income of each representative firm; from this one we can calculate the *cumulative_aggregate_income* (North/Centre/South) as the sum between the wealth of a considered year and the wealth produced in all previous years.

The last things to do in the *Setup* definition are both opening a new text file that, in this case, is not yet closed because it will be useful in the *Go* procedure, and introducing the function *to Graph*.

5.3.2 To Graph

The *graph* function is used to locate breeds in the interface. We established the all coordinates on both x and y-axis: in the left hand side of the screen, we located the representative firms with respect to their area of competence (North, Centre, and South).

```
to graph
  let xnwN 4
  let xpN 4
  let xnpN 4
  let xnwC 4
  let xpC 4
  let xnpC 4
  let xnwS 4
  let xpS 4
  let xnpS 4
  let ypN 32
  let ynpN 30
  let ynwN 24
  let ypC 16
  let ynpC 14
  let ynwC  11
  let ypS   7
  let ynpS 5
  let ynwS 2

  let xfN 2
  let xfC 2
  let xfS 2
  let yfN 25
  let yfC 13
  let yfS 4
```

Subsequently, we placed women in correspondence of their geographical area, near to their representative firm, dividing them in three groups: firstly, the part-time workers, secondly, the full-time ones and, lastly, the unemployed (iterating this procedure for each firm).

When the number of agents exceeds the maximum length of the screen, the further agents will be locate in the subsequent available line.

```
ask women
[ if work_area = 0
  [
  ifelse worker
  [
    ifelse ptimeworker
    [
      set xpN xpN + 0.5
      if xpN > max-pxcor
      [
        set xpN 4.5
        set ypN ypN - 1
      ]
    set xcor xpN
    set ycor ypN
    ]
    [
    set xnpN xnpN + 0.5
     if xnpN > max-pxcor
      [
      set xnpN 4.5
      set ynpN ynpN - 1
      ]
   set xcor xnpN
   set ycor ynpN
  ]
  ]
  [
   set xnwN xnwN + 0.5
   if xnwN > max-pxcor
    [
      set xnwN 4.5
      set ynwN ynwN - 1
      ]
 set xcor xnwN
 set ycor ynwN
]]]
```

```
ask women
  [ if work_area = 1
  [
  ifelse worker
  [
    ifelse ptimeworker
    [
      set xpC xpC + 0.5
      if xpC > max-pxcor
      [
        set xpC 4.5
        set ypC ypC - 1
      ]
    set xcor xpC
    set ycor ypC
    ]
    [
    set xnpC xnpC + 0.5
     if xnpC > max-pxcor
      [
      set xnpC 4.5
      set ynpC ynpC - 1
      ]
   set xcor xnpC
   set ycor ynpC
  ]
  ]
  [
   set xnwC xnwC + 0.5
   if xnwC > max-pxcor
    [
      set xnwC 4.5
      set ynwC ynwC - 1
      ]
 set xcor xnwC
 set ycor ynwC
]]]
```

```
ask women
  [ if work_area = 2
  [
  ifelse worker
  [
    ifelse ptimeworker
    [
      set xpS xpS + 0.5
      if xpS > max-pxcor
      [
        set xpS 4.5
        set ypS ypS - 1
      ]
    set xcor xpS
    set ycor ypS
    ]
    [
    set xnpS xnpS + 0.5
     if xnpS > max-pxcor
      [
      set xnpS 4.5
      set ynpS ynpS - 1
      ]
   set xcor xnpS
   set ycor ynpS
  ]
  ]
  [
   set xnwS xnwS + 0.5
   if xnwS > max-pxcor
    [
      set xnwS 4.5
      set ynwS ynwS - 1
      ]
 set xcor xnwS
 set ycor ynwS
]]]
end
```

Then, after the agent's location, we proceeded in creating two plots.

```
    set-current-plot "aggregate_income"
    set-current-plot-pen "aggregate_income_North'
    plot [aggregate_income] of firm (num)
    set-current-plot-pen "aggregate_income_Centre"
    plot [aggregate_income] of firm (num + 1)
    set-current-plot-pen "aggregate_income_South'
    plot [aggregate_income] of firm (num + 2)


    set-current-plot "cumulative_aggregate_income"
    set-current-plot-pen "cumulative_aggregate_income_North"
    plot (cumulative_aggregate_income_North)
    set-current-plot-pen "cumulative_aggregate_income_Centre"
    plot (cumulative_aggregate_income_Centre)
    set-current-plot-pen "cumulative_aggregate_income_South"
    plot (cumulative_aggregate_income_South)


end
```

The first one, called aggregate income, shows the annual trend of the aggregate income of each representative firm, while the second one depicts the trend of the cumulative aggregate income.

5.3.3 To Go

The main purpose of this part of the code is the creation of an interaction among agents.

Once increased of one year the timing of the model, we started to define the women renewal procedure. Considering the fact that we are interested in inquiring a population of age included between 20 and 44 years old (given that this period is the most relevant for researches related to this topic), we decided to substitute the older subjects of each go with new ones caught from the renewal dataset. Once removed from the corresponding category, we established a new larger size of these subjects to make more evident this procedure. Furthermore, we gave new women, taken from the ad hoc renewal file that reports only 20 years old subjects, the same information held by agents already interacting in the model. Considering that the size of this new file is relative small if compared with the original one, we inserted a command to verify if, during the reading procedure, the file has been reached the end: if it is the case, the file reading procedure will re-start from the beginning of the dataset.

```
to go
  set year year + 1
  ask women
  [set age age + 1
    if age > 44 [
      ask firm (num + work_area) [set nwomen nwomen - 1]
      ifelse worker[ifelse ptimeworker [ask firm (num + work_area)[set nptimeworker nptimeworker - 1]]
                                   ask firm (num + work_area)[set nfull timeworker nfull timeworker   1]]
                                   ask firm (num + work_area) [set nunemployed nunemployed - 1]]
      set size 1.3
      set ptime file read
      set skill file-read
      set work_day file-read
      set maternity file-read
      set work_area file-read - 1
      set birth_area file-read
      if file-at-end? [file-close
                       file-open "datasetrenewalLABOR.txt"]
```

For simplicity, here we did not set the agents' age as the difference between the birth year and the actual one, as in the *Setup* procedure, but we fixed it directly at 20.

While for the definition of worker, part-time worker, delay-return, and neo-mother we used the previous mentioned procedure, here we decided to set arbitrarily the mother condition as false, considering that a representative sample of 20 years old people does not show mothers within it.

If the young woman did not work at the moment of interview, we gave her the possibility of becoming worker. It happens only if the number of full-time workers operating in the firm of competence is inferior to the maximum amount of available job positions, given, in this case, the variable *nfull-time demand* (for further details look at the *Setup* procedure). To be more concrete, we considered that an agent, previously outside from the labour market, could re-enter only if some available work positions appear in the market.

Once defined both formal and informal child-care availability and the education level, we finished the renewal procedure by setting the women size at the original level and by asking to the firms to update the count for the number of subjects operating in each category.

```
  set age 20
  ifelse work_day > 200 [set worker true] [set worker false]
  set mother false
  set delay-return -1
  ifelse maternity = 1 [set neomother true][set neomother false]
  ifelse worker and (ptime = 1) [set ptimeworker true][set ptimeworker false]
  ifelse neomother
    set mother true
    set color violet][set color green]
  if not worker [if [nfull-timeworker] of firm (num + work_area) < [nfulltimedemand] of firm (num + work_area)
                 [set worker true ]]
  ifelse random-float 1 < informal-childcare [set grandparents true] [set grandparents false]
  ifelse random-float 1 < childcare-coverage [set c-care true] [set c-care false]
  if skill <= 2 [set low-formation true ]
  if skill > 2 [set medium-formation true]
  if skill = 5 [set high-formation true]
  ifelse worker[ifelse ptimeworker [ask firm (num + work_area)[set nptimeworker nptimeworker + 1]]
                [ask firm (num + work_area)[set nfull-timeworker nfull-timeworker + 1]]]
                [ask firm (num + work_area) [set nunemployed nunemployed + 1]]
  ask firm (num + work_area) [set nwomen nwomen + 1]


set size 0.7
]
```

Additionally, the procedure to become mother during the simulation was introduced: if a random floating number included between 0 and 1 is inferior to the fertility rate of the year, the maternity event will take place and the individual will be set as neo-mother, and then mother. Once defined, with the usual procedure, the formal/informal childcare provision, we made a distinction between the agents having available one or both services (not entering in the *only-part-timedisposable* category)

and those having neither of them (defining them *only-part-timedisposable*). In the first category we inserted women that are substantially indifferent to the features of the job position offered by the firms, due to their high services availability; the second category, instead, includes those subjects that, in order to remain in the labour market, are forced to consider only part-time offers.

Considering the last category, we set its delay-return to 3 (it can be imagined that, after 3 years, the duties of a neo-mother will decrease in their intensity, becoming easier to conciliate family and work efforts). Then, we proceeded in defining their working condition: as we have seen before, the subject will receive a work only if the actual total number of part-time workers is inferior to the benchmark level, set in the *Setup* procedure.

```
ifelse random-float 1 < item (age - 20) fertility
[ set mother true
  set neomother true] [set neomother false ]
if mother [set color pink]
if neomother [set color violet]
if (neomother and worker and (not ptimeworker))
  [
    ifelse random-float 1 < childcare-coverage [set c-care 1][set c-care 0]
    ifelse random-float 1 < informal-childcare [set grandparents 1] [set grandparents 0]
    ifelse (c-care = 0) and (grandparents = 0) [set onlypart-timedisposable true]
                                               [set onlypart-timedisposable false]
    if onlypart-timedisposable
    [
      set delay-return 3
      ifelse [nptimeworker] of (firm (num + work_area)) < [nparttimedemand] of (firm (num + work_area))
      [set ptimeworker true
        ask firm (num + work_area) [set nptimeworker nptimeworker + 1
                                    set nfull-timeworker nfull-timeworker - 1
        ]
      ]
    [set worker false
     ask firm (num + work_area) [set nfull-timeworker nfull-timeworker - 1
                                 set nunemployed nunemployed + 1]]]
    ]
```

Looking again at the instrumental variable *delay-return*, it represents a sort of counter tracing the years during which women could be characterized by a difficult situation (*only-part-time-disposable*). At each *Go*/year, if this value is greater that 0 will decrease of one unit, until a value corresponding to 0 will be reached: at this point, the *delay-return* will be reset to -1 (a value describing the situation of a normal full-time worker).

We also added a mechanism to re-insert unemployed women in the economy through the usual instrument of the random floating number inferior to the re-entering percentage set in the model. Since in this category there are both voluntary (that

systematically prefer to no enter in the labour market) and involuntary unemployed, we decided that the percentage of agents trying to re-enter in the job world uses the part-time instrument. This decision is supported by the analysis of the reality: especially in the Italian context, in fact, many women are unemployed in reason of their cultural heritage that exiles the natural female dimension within the house walls. From this point of view, the part-time can be interpreted as a compromise between the old woman interpretation and her emancipation.

```
if delay-return > 0 [set delay-return delay-return - 1]
if delay-return = 0 [ set delay-return -1
  set worker true
  ifelse ptimeworker [ask firm (num + work_area) [set nptimeworker nptimeworker - 1]]
                     [ask firm (num + work_area) [set nunemployed nunemployed - 1]]
  set ptimeworker false
  ask firm (num + work_area) [set nfull-timeworker nfull-timeworker + 1]]


 if not worker
 [if random-float 1 < reenteringunemployed

   [if [nptimeworker] of firm (num + work_area) < [nparttimedemand] of firm (num + work_area)
     [ set worker true
       set ptimeworker true
       ask firm (num + work_area) [
       set nptimeworker nptimeworker + 1
       set nunemployed nunemployed - 1]]]]
```

In the final part of the code, we implemented the method for counting the wealth generated by the subjects interacting in the model (see at *Setup* procedure comment). We started from updating the value of the mean wage for each female category (inserted in the *Setup* procedure) considering the actual annual inflation rate that is 2.2%, setting it as the previous value multiplied by 1.022.

```
     let id who
     ifelse worker [ifelse ptimeworker [ set compensationP 13 * 1.022]
       [set compensationF 25 * 1.022 ]]
     [set compensationU 0 ]

     ifelse worker
     [ifelse ptimeworker
       [ask firm (num + work_area) [set aggregate_income aggregate_income + [compensationP] of woman id]]
       [ask firm (num + work_area)  [set aggregate_income aggregate_income + [compensationF] of woman id]]]
     [ask firm (num + work_area) [set aggregate_income aggregate_income + [compensationU] of woman id]]
]
```

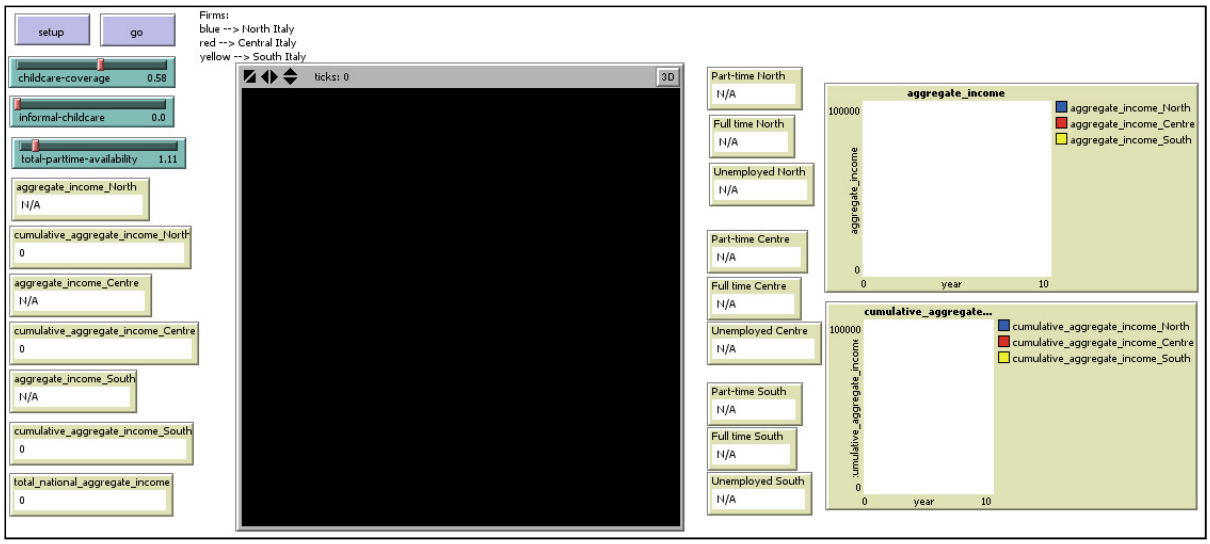
Then, we asked the model to re-count the value for the aggregate income of each representative firm with the same previously adopted procedure. From this value, we

proceeded also to compute the *yearly_total_aggregate_income*, the *cumulative_aggregate_income* and the *total_national_aggregate_income*.

```
  set yearly_total_aggregate_income_North [aggregate_income] of firm (num)
  set yearly_total_aggregate_income_Centre [aggregate_income] of firm (num + 1)
  set yearly_total_aggregate_income_South [aggregate_income] of firm (num + 2)

  set cumulative_aggregate_income_North cumulative_aggregate_income_North + yearly_total_aggregate_income_North
  set cumulative_aggregate_income_Centre cumulative_aggregate_income_Centre + yearly_total_aggregate_income_Centre
  set cumulative_aggregate_income_South cumulative_aggregate_income_South + yearly_total_aggregate_income_South

  set total_national_aggregate_income cumulative_aggregate_income_North
                                      + cumulative_aggregate_income_Centre
                                      + cumulative_aggregate_income_South

  graph

end
```

5.4 The Interface

This part of the model allows us to have a more immediate picture of the obtained results.



The centre of this space is an area in which we can depict the graphical locus of interaction among firms and women: these last could be grouped by taking into account their geographical proveniences and worker conditions.

On the left hand side, we inserted the buttons, necessary to initialize the *Setup* and *Go* procedures, the counters for *aggregate_income* and *cumulative_aggregate_income* of each representative firm and, lastly, a monitor showing the value of the *total_national_aggregate_income*.

On the right hand side, additionally to the counters for each female category of each firm area, we can observe two graphs: the upper one represents the path, over time, of the aggregate income of each firm, reporting this measure as a continuous flux; the lower one, instead, reports the *cumulative_aggregate_income* path, considering the value of each year as the sum of all the previously considered ones.

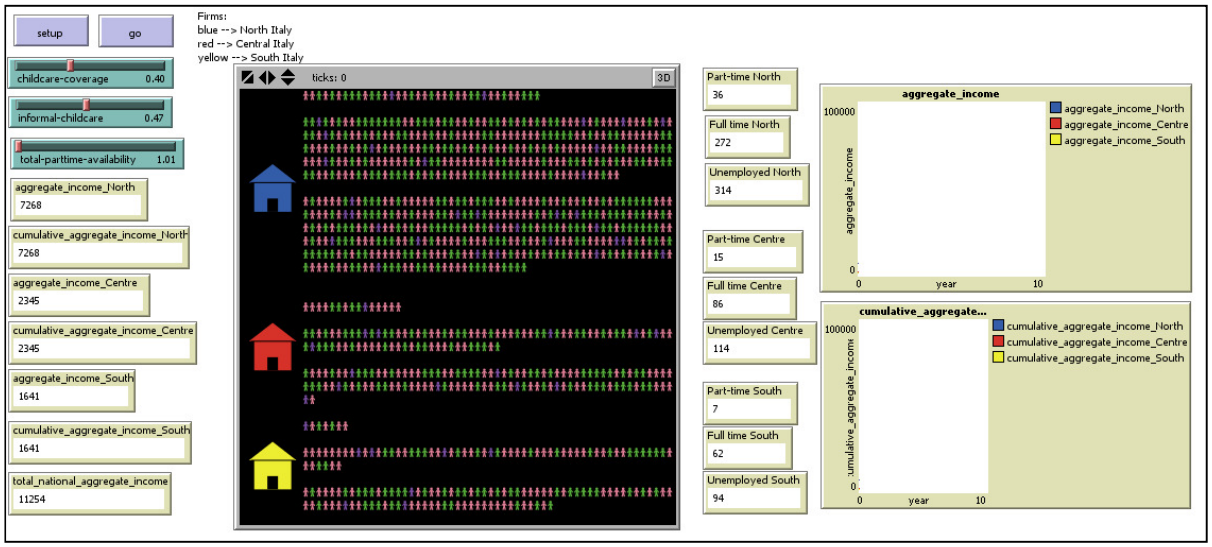
5.5 The observations

Once having analyzed the code generating the simulation, we have to look at the different situations depicted by changing the level of the three relevant parameters (part-time availability, both formal and informal childcare services) able to shock the final results.

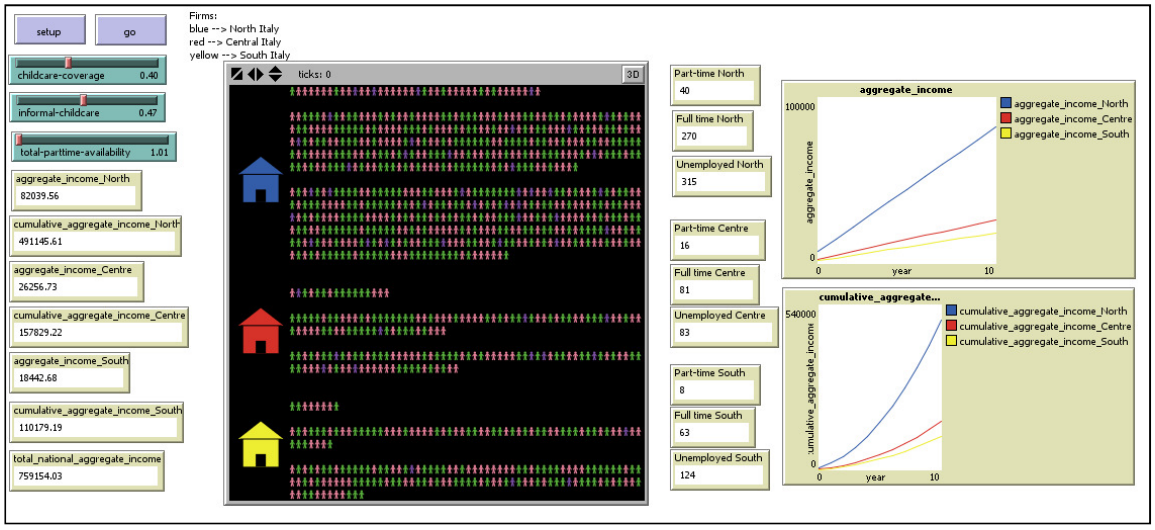
Particularly, we start by showing a real circumstance whose evidence could be disrupted by changing the variables levels. We proceed considering the original case but with a higher level of part-time availability followed by one characterized by very low level of both formal and informal childcare; then, we analyze an intermediate case with a low level of informal childcare but with high levels of both formal childcare services and part-time availability. Lastly, we treat two opposite extreme cases: the first one is the extreme negative, where all conciliation instruments are set at very low; the second one, the desirable but quasi utopian, where the levels of all variables are very high.

Observation 1. First of all, as said previously, we have to analyse the situation describing the reality coming from the dataset information. In this case, we have chosen a level of part-time representative of the real part-time employment in each Italian area by putting the correspondent slider at a very low level (without considering, in this way, any variation with respect to the reality). Concerning the other two discretional variables, we have decided two levels considered as mean by the literature on this field: for the informal childcare the level is 0.47 (approximated with 0.5) and, for the formal childcare services availability, it is fixed at 0.40.

We start by looking at the *Setup* procedure where the women employed in a full-time job are respectively 272 in the North area, 86 in the Centre and 62 in the South; the unemployed are respectively 314, 114 and 94, while the part-time ones are respectively 36, 15 and 7. These last values indicate a sort of benchmark availability of part-time positions in each area of interest.



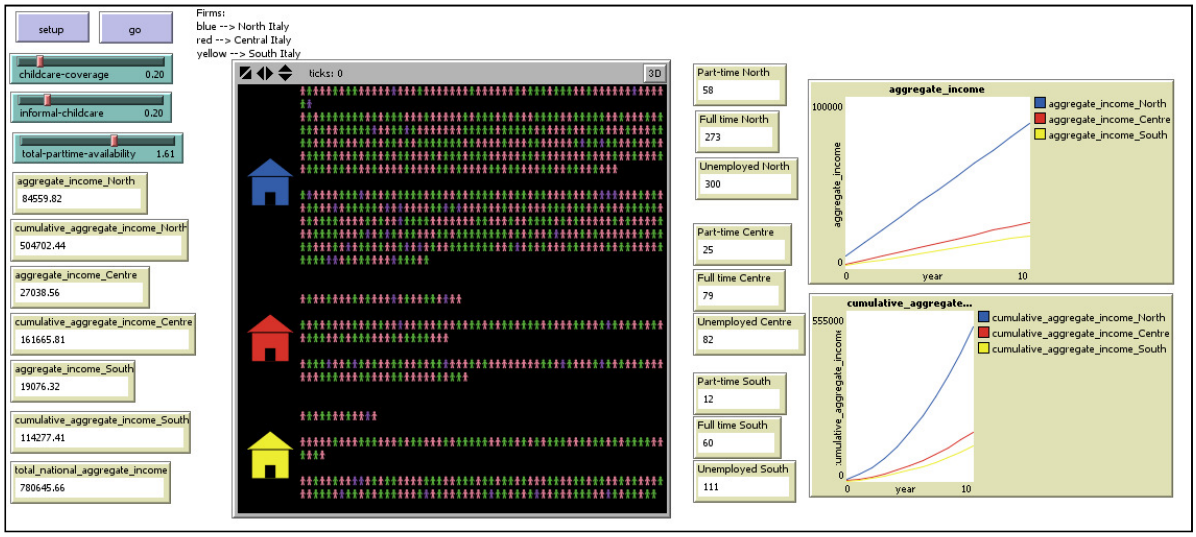
Under these conditions, we can see that, after ten years (and, so, ten *Go*), the number of part-timer women is the same as in the *Setup*, underlining the fact that this typology of job is highly requested in the market and, for this reason, no more positions are available. To make an evaluation of an economy characterized by these features, we have to look at the levels of the income indicators. We can observe the aggregate income levels and the correspondent cumulative values. These paths are represented in the two plots in the right hand side of the interface. The first one shows a linear increasing trend, also if attested at different levels characterizing each Italian area (the highest values characterize the North area); while, concerning the second one, we have to focus our attention on its particular exponential patterns, typical of a cumulative function.



Observation 2. The second analysed case is characterized by a situation equal to the previous one but with a higher part-time availability in the firm structure. By making these changes, we can see that the number of part-time workers is higher than before underlining, in this way, that, *ceteris paribus*, a more intensive supply of part-time jobs implies an increased number of users and a low number of women outside the labour market. This is also accentuated by the aggregate income levels, attested at a higher level than in the previous case, reflecting it in the national total aggregate income.

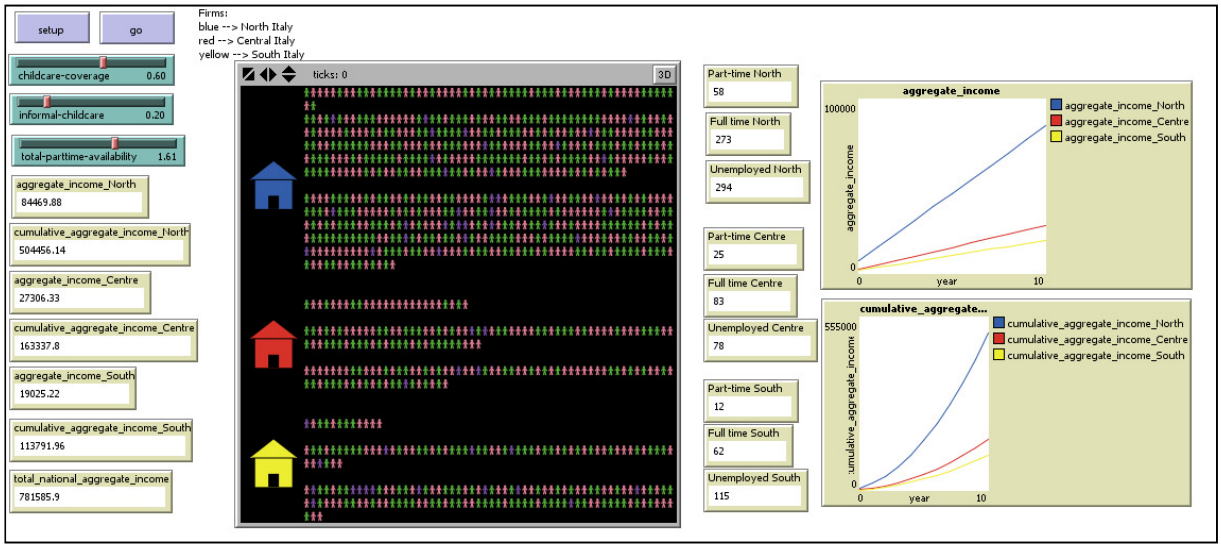
By a graphical point of view, both aggregate income and its cumulative show the same path than before even if in this case they are more marked.

Observation 3. This case represents a situation in which there are very low levels of both formal and informal childcare accompanied with very high level of part-time availability in the labour market. Also in this circumstance, we can note that women benefiting from part-time availability are a large number: this underlines that, under the scarcity of other strategies to conciliate work and family, women search for part-time job, a good way to reduce the trade-off between these two life spheres. This high employment thanks to the part-time jobs is able to sustain the entire economy even if it is the only instrument that women can use, by avoiding the collapse of the system due to a possible increase of the unemployment categories.

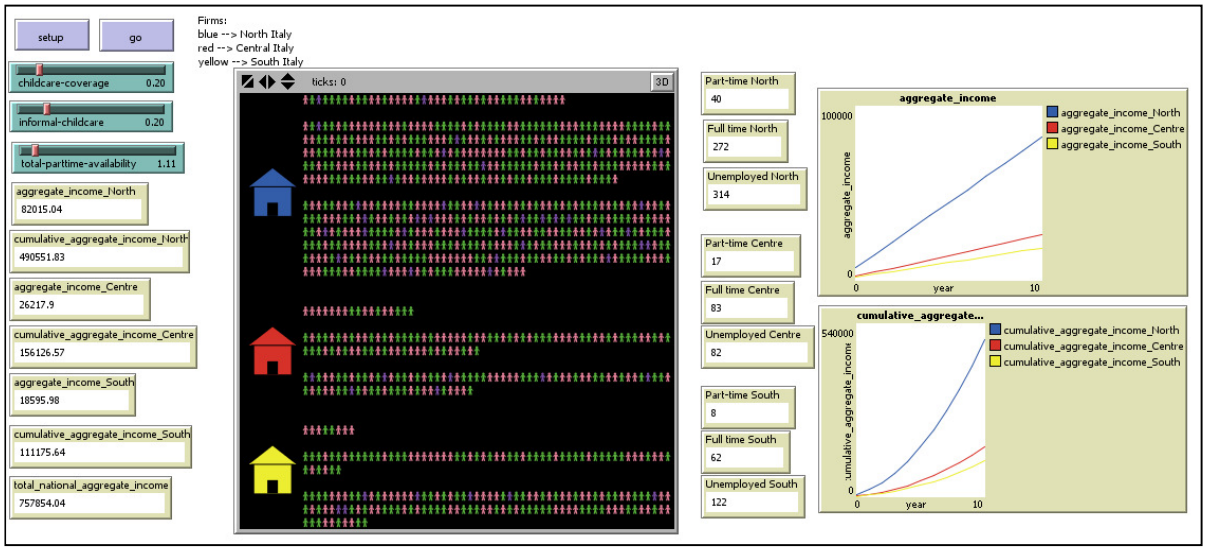


Observation 4. Further relevant considerations are possible when we consider a situation in which the availability of both formal childcare services and part-time are much spread in the considered areas, while the informal childcare touches very low levels. Here, we can observe that the combination of the two positive variables implies a huge increase in the total national income and in the relative aggregate incomes. This could suggest the weak relevance of the presence of relatives (especially grandparents) as helpful to look after children especially in the first years of life.

Probably, their role can be easily substituted in a situation in which there is a high presence of the other two resources.

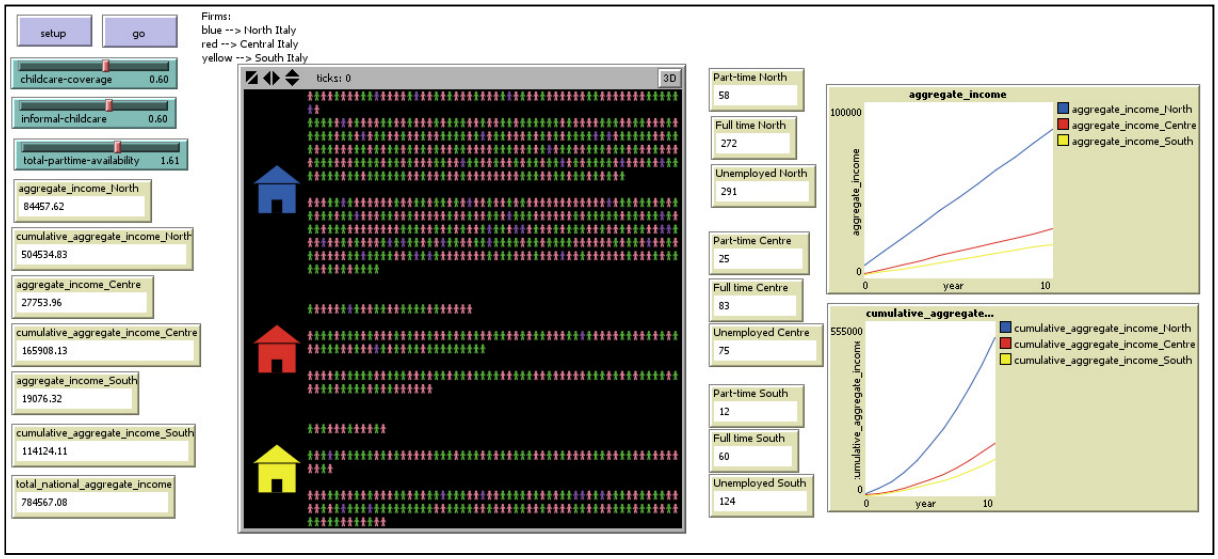


Observation 5. At this point, we think that it is appropriate to analyze an extreme case consisting in the worse existing situation: very low levels of all variables. This could be considered the worse case due to the fact that woman has no sufficient resources to conciliate both family and work. This has repercussions on her time management and in many cases, this implies her exit from the labour market to look after the children who, otherwise, would be left alone. We can see it by looking at the level of total national aggregate income that touches the lowest one considered until now, even if all available part-time positions are totally covered. This result underlines the fact that the presence of conciliation instruments is useful not only for each mother's time management but also for the whole economy.



Observation 6. On the other side, instead, we note the opposite results when we consider a quasi-utopian case in which there is a high availability of the three variables. Here it is possible to see that the there are many part-time positions and they are all covered; the total national aggregate income is attested at very high levels even more accentuated by the shape of the cumulative aggregate income of each Italian area, especially in the northern one, that depicts a very steep exponential pattern.

This situation could be considered the best one where women are able to conciliate both family and work being to whole economy's benefit.



6. The Robustness of the model

Once commented the results for the simulation, we proceed in testing the robustness of the model, through the usage of an appropriate program that bases the maximization procedure on the concept of genetic algorithm. Before starting with the comments of the obtained results could be useful going more in details through the genetic algorithm concept and the main features of Behavior Search.

6.1 Genetic algorithm

“Living organisms are consummate problem solvers. They exhibit a versatility that puts the best computer programs to shame. This observation is especially galling for computer scientists, who may spend months or years of intellectual effort on an algorithm, whereas organisms come by their abilities through the apparently undirected mechanism of evolution and natural selection. Pragmatic researchers see evolution's remarkable power as something to be emulated rather than envied. Natural selection eliminates one of the greatest hurdles in software design: specifying in advance all the features of a problem and the actions a program should take to deal with them. By harnessing the mechanisms of evolution, researchers may be able to "breed" programs that solve problems even when no person can fully understand their structure. Indeed, these so-called genetic algorithms have already demonstrated the ability to made breakthroughs in the design of such complex systems as jet engines.” (from Holland (1992), p. 44).

More concretely, a genetic algorithm (GA), is a search heuristic that mimics the process of natural evolution. This heuristic is routinely used to generate useful solutions to optimization and search problems. Genetic algorithms belong to the larger class of evolutionary algorithms (EA), which generate solutions to optimization problems using techniques inspired by natural evolution, such as inheritance, mutation, selection, and crossover.

6.1.1 History

Computer simulations of evolution started as early as in 1954 with the work of Nils Aall Barricelli, who was using the computer at the Institute for Advanced Study in Princeton, New Jersey. His 1954 publication was not widely noticed. The Australian quantitative geneticist, Alex Fraser, starting his work in 1957, published a series of papers on simulation of artificial selection of organisms with multiple loci controlling a measurable trait. From these beginnings, computer simulation of evolution by biologists became more common in the early 1960s, with methods that were described in books by Fraser and Burnell (1970) and Crosby (1973). Fraser's simulations included all the essential elements of modern genetic algorithms. In addition, Hans-Joachim Bremermann published a series of papers in the 1960s, adopting also a population of solution to optimization problems, undergoing recombination, mutation, and selection. Bremermann's research also included the elements of modern genetic algorithms. Other noteworthy early pioneers can be cited: Richard Friedberg, George Friedman, and Michael Conrad. Even if Barricelli, in the work he reported in 1963, had simulated the evolution of ability to play a simple game, artificial evolution became a widely recognized optimization method as a result of the work of Ingo Rechenberg and Hans-Paul Schwefel in the 1960s and early 1970s. Rechenberg's group was able to solve complex engineering problems through evolution strategies. Another approach that has to be mentioned is the evolutionary programming technique of Lawrence J. Fogel, which was proposed for generating artificial intelligence. Evolutionary programming, originally, used finite state machines for predicting environments, and used variation and selection to optimize the predictive logics.

Being more precise, genetic algorithms became popular through the work of John Holland in the early 1970s, and particularly thanks to his publication “Adaptation in Natural and Artificial Systems” (1975). Holland and his students conducted the work, started with the study of the cellular automata, at the University of Michigan. Holland introduced a formalized framework for predicting the quality of the next generation, known as Holland's Schema Theorem (for further details see at the below box). Research in GAs remained largely theoretical until the mid-1980s, when The First International Conference on Genetic Algorithms was held in Pittsburgh, Pennsylvania.

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6.1.2 Biological background

All living organisms consist of cells. In each cell there is the same set of chromosomes. Chromosomes are strings of DNA and serve as a model for the whole organism. A chromosome consists of genes, blocks of DNA. Each gene encodes a particular protein. Basically can be said that each gene encodes a trait. Possible settings for a trait are called alleles. Each gene has its own position in the chromosome. This position is called locus.

Complete set of genetic material (all chromosomes) is called genome. Particular set of genes in genome is called genotype. The genotype is, with later development after birth, the base for the organism's phenotype, its physical and mental characteristics, such as eyes color, intelligence etc.

During reproduction, first occurs recombination: genes from parents form in some way the whole new chromosome. The new created offspring can then be mutated and the fitness of this organism is measured by success of itself in its life.

6.2 Methodology

In a genetic algorithm, a population of strings (the genotype), which encode candidate solutions (phenotypes) to an optimization problem, evolves toward better solutions. Traditionally, solutions are represented in binary way as strings of 0s and 1s, but other encodings are also possible. The evolution usually starts from a population of randomly generated individuals and takes places in generations. In each of these last ones, the fitness of every individual in the population is evaluated; multiple individuals are stochastically selected from the current population (based on their fitness), and modified (recombined and possibly randomly mutated) to form a new population. The new population is then used in the next iteration of the algorithm. Commonly, the algorithm terminates when either a maximum number of generations has been produced, or a satisfactory fitness level for the population has been reached. If the algorithm has terminated due to a maximum number of generations, a satisfactory solution may or may not have been reached.

Genetic algorithms find application in bioinformatics, phylogenetics, computational science, engineering, economics, manufacturing, mathematics, physics and other fields.

A typical genetic algorithm requires:

1. Genetic representation of the solution domain,
2. Fitness function to evaluate the solution domain.

A standard representation of the solution is as an array of bits. Arrays of other types and structures can be used in essentially the same way. The main property, that makes these genetic representations convenient, is that their parts are easily aligned due to their fixed size.

The fitness function is defined over the genetic representation and measures the quality of the represented solution. It is always problem dependent: once we have the genetic representation and the fitness function defined, GA proceeds to initialize a population of solutions randomly, then improve it through repetitive application of mutation, crossover, inversion and selection operators.

6.2.1 Initialization

At the begin many individual solutions are randomly generated to form an initial population. The population size depends on the nature of the problem, but typically contains several hundreds or thousands possible solutions. Traditionally, as said before, the population is generated randomly, covering the entire range of possible solutions (the search space). Occasionally, the solutions may be "seeded" in areas where optimal solutions are likely to be found.

6.2.2 Selection

During each successive generation, a proportion of the existing population is selected to breed a new generation. Individual solutions are evaluated through a fitness-based process, where fitter solutions are typically more likely to be selected. Certain selection methods rank the fitness of each solution and preferentially select the best available ones.

6.2.3 Reproduction

Reproduction implies the generation of a second-generation population of solutions from those selected through genetic operators: crossover (also called recombination) and/or mutation.

For each new solution to be produced, a pair of "parent" solutions is selected for breeding from the pool selected previously. By producing a "child" solution using the above methods of crossover and mutation, a new solution is created which typically shares many characteristics of its "parents". New parents are selected for each new child, and the process goes on until a new population of solutions of appropriate size is generated. Although reproduction methods, based on the use of two parents, are

more "biology inspired", some research suggests that, to reproduce a good quality chromosome, more than two "parents" are better to be used.

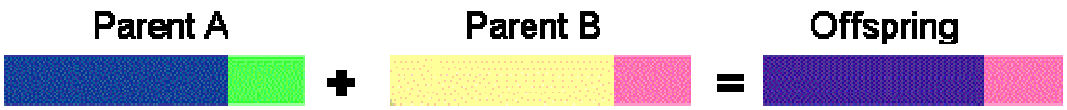
These processes ultimately result in the next generation population of chromosomes, different from the initial one. Generally the average fitness will be increased by this procedure for the population, since only the best organisms from the first generation are selected for breeding, along with a small proportion of less fitting solutions, for reasons already mentioned above.

In particular: “The universe of all possible strings can be considered as an imaginary landscape; valleys mark the location of strings that encode poor solutions, and the landscape's highest point corresponds to the best possible string. One conventional technique for exploring such a landscape is hill climbing: starting at some random point and, if a slight modification improves the quality of your solution, the process will go on in that direction; otherwise, in the opposite one. Complex problems, however, make landscapes with many high points. As the number of dimensions of the problem space increases the countryside may contain tunnels, bridges and even more convoluted topological features. Finding the right child or even determining which way is up becomes increasingly difficult. In addition, such search spaces are usually enormous.” (from Holland (1992), p.45)

6.2.4 Crossover

Crossover is a genetic operator used to vary the programming of a chromosome or chromosomes from one generation to the next. It is analogous to reproduction and biological crossover, upon which genetic algorithms are based. Two different typology of it exist: one-point crossover and two-point crossover.

A single crossover point on both parents' organism strings is selected. All data beyond that point in either organism string is swapped between the two parent organisms. The resulting organisms are the children:



11001011+11011111 = 11001111

Figure .1: Single crossover example

Two-point crossover calls for two points to be selected on the parent organism strings. Everything between the two points is swapped between the parent organisms, rendering two child organisms:

11001011 + 11011111 = 11011111

Figure .2: Two-point crossover example

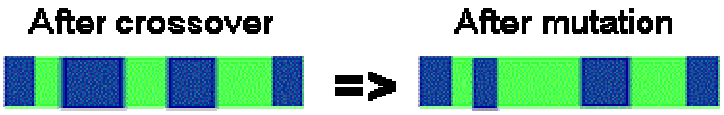
6.2.5 Mutation

Also mutation is a genetic operator used to maintain genetic diversity from one generation of a population of algorithm chromosomes to the next. It is analogous to biological mutation.

The classic example of a mutation operator involves a probability that an arbitrary bit in a genetic sequence will be changed from its original status. A common method of implementing the mutation operator involves generating a random variable for each bit in a sequence. This random variable traces whether or not a particular bit will be modified. This mutation procedure, based on the biological point mutation, is called single point mutation. Other types are inversion and floating point mutation. When the gene encoding is restrictive as in permutation problems, mutations are swaps, inversions and scrambles.

The purpose of mutation in GAs is preserving and introducing diversity. Mutation should allow the algorithm to avoid local minima by preventing the population of chromosomes from becoming too similar to each other, thus slowing or even stopping evolution. This reasoning also explains the fact that most GA systems avoid, only taking

the fittest of the population in generating the next, a random (or semi-random) selection with a weighting toward those that are fitter.



11001001 => 10001001

Figure .3: Mutation example

6.3 Active Non-linear Tests (ANTs) of Complex Simulation Model

Such models provide a way to analyze complex systems, both featured by large parameter spaces and no-linear interactions; but, unfortunately, the same characteristics that make computational methods so appealing, make also extremely difficult testing them with the traditional techniques.

Some potential applications of ANTs model include:

- Multivariate sensitive analysis, that uncovers model sensibilities to a parameter groups;
- Model Breaking and Validation, that explores conditions under which a model breaks down;
- Extreme Case Scenario Discovery, that aims to find best or worst scenarios that could arise, given some reasonable chosen parameters;
- Policy Discover, for achieving some desirable results in the model context.

The basic idea behind all these types of instruments is to use a non linear algorithm to search among a set of reasonable model disturbances, with the aim of maximizing the distance from the original model predictions and that obtained through the perturbed one, presuming to include in the test operations the variables of greatest importance for the modeler.

Because ANTs methods make, in their work, comparisons across sets of parameter variables, they are also able to detect important no-linear relationships among the parameters (that, otherwise, typically go unnoticed).

With these information, the model can be redefined or, alternatively, additional efforts will be focused in better estimating the key assumptions.

In order to implement ANTs, the modeler can use a no-linear optimization algorithm to search for perturbations in the model's formulation. Once established the algorithm, it can be chosen on which aspects of the model formulation we want to focus.

The basic algorithms have the following forms:

1. Let $M_h(p)$ that gives the implications for the model for hypothesis *h* under assumptions *p*. The hypothesis is any conclusion of interest coming from the model and the assumptions can include the model parameters, structural elements, etc.
2. Define Δp to be the set of allowable perturbations to the model's assumptions;
3. Let $\Pi(M_h(p), M_h(\hat{p}))$, be an objective function designed to illuminate the model behavior surrounding the hypothesis *h.* (considering $\hat{p}$ the original assumptions of the model);
4. Use an optimization algorithm to maximize $\Pi(M_h(p), M_h(\hat{p}))$.

Depending on the forms used, the objective function may be ripe with local optima. Additionally, discontinuities may arise due to the nature of the simulations parameters or to the type of disposable disturbances. Thus, finally, it can be useful economizing on the number of iterations of the actual model in order to obtain results in the less possible time.

One of the most spread algorithms is the hill-climbing one that works choosing an initial random solution within the search space. At each algorithm's iteration, a new solution is randomly chosen from a neighborhood. If the new solution results in a higher value of the objective function, it becomes the new status quo (otherwise the status remains unchanged). The algorithm iterates the procedure for a fixed number of iterations. At the end of the operation, the last status quo is used as the ultimate solution.

GAs (treated in the other chapter) have proven to be an effective search technique in complex optimization problem. In a GA, initially the solution populations are created randomly, then, each solution is tested, receiving a

message of “fitness”. Subsequently, it creates a new solution population by both reproducing old solutions (ranked with respect their fitness) and adding some new solutions through new genetic operators. Once created a new solution, there will start a new “generation”. The reproduction and the modification stages of GAs result in a useful sampling scheme on the key patterns underlying possible effective solutions.

Obviously, GAs alone are not able to provide and grant for quality modeling. Careful thoughts will always be needed from the modeler point of view in order to insure useful models.

6.3.1 The Search Space

The optimization algorithm is used to search over a space of allowable perturbations in the model simulation, which choice will determine what aspects of the model have to be tested.

One of the most useful search spaces is a sort of reinterpretation of the original parameter used in the model. In this case, the extent of neighborhood can be determined by uncertainties accompanying the measurement of each parameter (assuming for example, that each parameter is measured with a 5 percent error).

Additionally, ANTs could perform searches over different formulations of the model underlying equations.

One way to implement this idea is to allow arbitrary feedback loops to develop in the model by incorporating perturbation terms into rate equation for each state variable (from Miller, p.3, 1998).

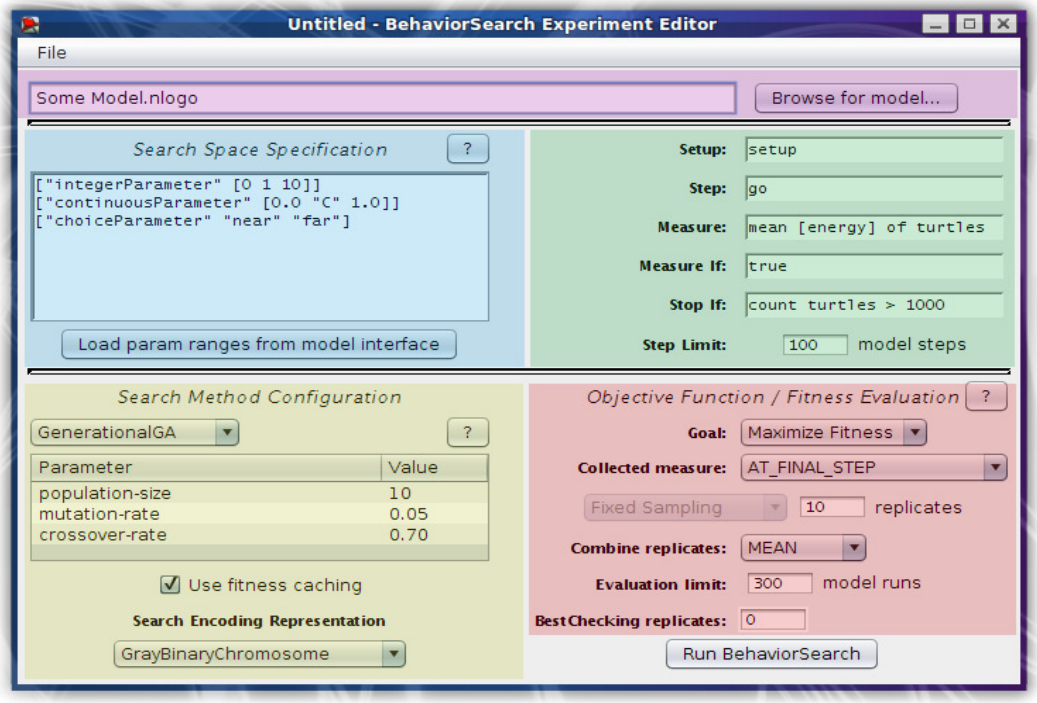
6.4 BehaviorSearch

Looking at the disposable instruments to implement the previous cited ANTs we have opted for BehaviorSearch, that is a open-source cross-platform tool, implemented in Java, with the aim of helping the automating exploration of agent-based models (ABMs), by using genetic algorithms and other heuristic techniques to search the parameter-space. BehaviorSearch interfaces with NetLogo ABMs development platform, to provide a low-threshold way to search for combinations of model parameter settings that will result in a specified target behavior. The model exploration takes place through many steps:

- Specify the model file;
- Design a quantitative measure for the behavior you're interested in;
- Choose parameters to vary and the allowed ranges;
- Choose a search algorithm and run it, returning the best results discovered;
- Examine the results to find parameters most affecting the behavior.

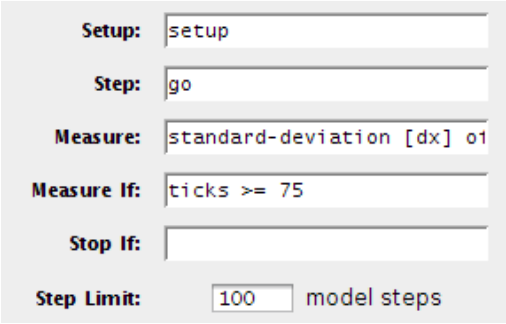
6.4.1 How to use BehaviorSearch

The first thing that you encounter, opening for the first time BehaviorSearch, is the window "BehaviorSearch Experiment Editor". It is centered around the paradigm of an experiment, which contains all of the information necessary to specify how the search should be performed on a model.



The picture represents the initial interface of BehaviorSearch in which:

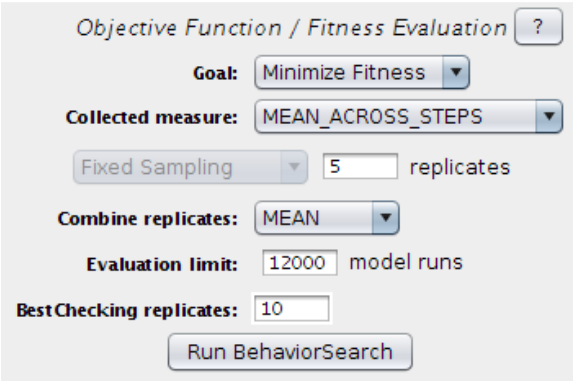
- The upper string contains the address of the Netlogo file on which we want to base our analysis;
- The upper right-hand side is useful to specify several arguments regarding how the model should be run, so that it is possible to collect data that will help us to search for the model conditions that cause the convergence;



We can comment the main fields of this window:

1. ***Setup*, a** NetLogo command to setup the model (typically called "Setup procedure");
2. ***Step***, a NetLogo command to be run over and over again (known as "Go procedure")
3. ***Step limit*,** the limit on the number of times at which the *step* commands will be run.

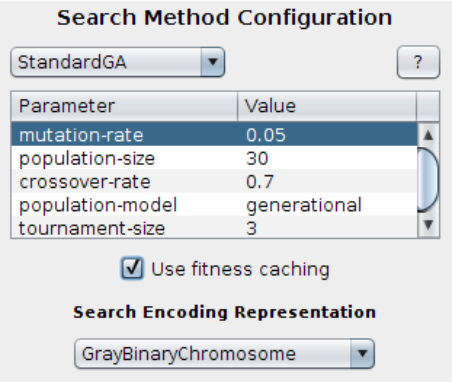
- The upper left-hand side of the screen reports all the available buttons on the Netlogo interface, once transformed into parameters code;
- The lower right-hand side of the screen specifies how many times to run the model, as well as how to take the data collected from the model runs and turn it into an objective function for the search method to minimize or maximize;



In this area we have to fill in different information, such as:

1. ***Goal***, useful to determine if we want to maximize or minimize our search;
2. ***Collected measure,*** to collect the measure multiple times;
3. ***Sampling*****,** to perform multiple replicate runs and collect behavioral measures from each of them;
4. ***Combine replicates,*** to combine the results if there are multiple replicated runs of the model. In order to do this, it is possible to use the mean, the median, the minimum, the maximum or the variance;
5. ***Evaluation limit,*** to fix how many total model runs should be done before stopping the process;
6. ***BestChecking replicates,*** the number of additional replicated model runs that should be performed to get an unbiased estimate of the true objective function value, each time the search algorithm finds a new set of parameters that it thinks is better than any previous set;

- The lower left-hand side of the screen specifies which search algorithm and search space encoding have to be used. The search algorithm determines in which order the different parameter settings will be tried.

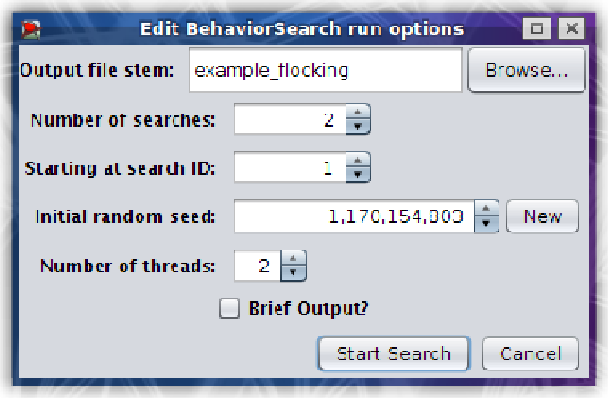


BehaviorSearch includes three search algorithms:

1. ***RandomSearch,*** which randomly generates one set of parameters after another, computing the objective function for each turn, returning, at the end, the best settings founded;

2. ***MutationHillClimber,*** which starts with a random location in the search space, and then repeatedly generates a neighbouring location (using a mutation operator) moving to that new location only if it is better than the old one. It uses also the **mutation-rate** controlling for the probability of mutation;
3. ***StandardGA***, a classic Genetic Algorithm, usually applied by default by the program, which can operate on any of the available search representations.

Once set all of those options for choosing how the search procedure will be performed, we need to hit save the search protocol and hit the *Run BehaviorSearch* button located in the lower right corner of the window. In doing it, a further window, necessary to choose some additional options relating to the search running configuration, appears.

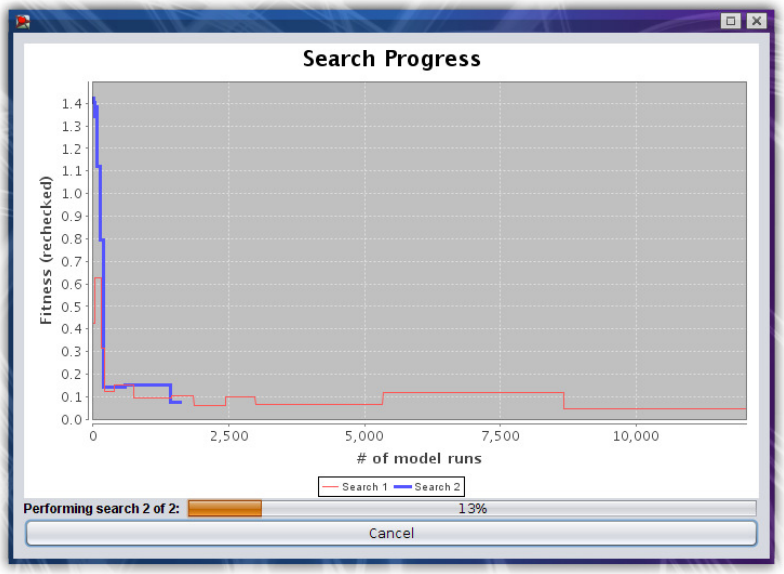


In this window there are some different voices:

- ***Output file stem,*** that indicates where the data, output of the search, should be saved;
- ***Number of searches***, indicating how many times the whole search process should be repeated: in many cases, in fact, a single search may not find the best parameter and so additional searches will improve confidence;
- ***Starting at search ID,*** only affecting the ID numbering in the output files;

- ***Initial random seed,*** used for the pseudo-random number generator, to start the first search and to reproduce the exact same search later.
- ***Number of threads***, determining how many threads are conducted each time, t can significantly affect the speed of the search process;
- ***Brief Output?,*** to suppress the creation of the two largest output files.

While the finding procedure is running, a progress dialog is possible to see:



The most significant part is the plot showing the searches' progress: on the x-axis there is the number of model runs that the search has performed; on the y-axis there is the current best fitness function value that the search has discovered so far. If *BestChecking* replicates are used, the plot shows the independently "re-checked" fitness values. If not, then the plot will show the fitness values that the search algorithm observed.

6.5 The reasons for the test

Even if, through the evaluation of the observations, the relationship between wealth produced in the economy and part-time availability appears clear, the linkages between the variables involved have to be evaluated. Particularly it can be underlined that between these variables there exist some non-linear and inverse relationships that potentially can undermine the results' significance.

In order to test the validity of the model through Behavior Search we have, first of all, to define the variables that can be optimized and the one representing the benchmark towards which evaluating them.

Referring to the variables to be maximized we have chosen: part-time availability, formal child-care coverage and informal child-care availability. The reasons of this choice stand on the multiple relationships between each other, that there are briefly resumed in:

- Part-time and formal child-care: surely, at a first approach, it can be interpreted as a negative linkage, since at the increase of the part-time availability the need for a formal child-care will decrease in absolute terms or, at least, in relative ones; in other words, if there are more part-time positions, it will be required an inferior amount of child-care (especially if expressed in term of hours). However, by another point of view, we have also to consider that, even in presence of part-time availability, at least a minimum amount of child-care hours will be required; then, in a sort of sense, an increase in part-time availability could have been followed by an increase in child-care provision;
- Formal and informal child-care provision. These two variables can be interpreted as perfect substitutes in the provision of care services (probably the difference among a child-care service offered by the grandparents or by specialized figures stands on the cultural and personal preferences of the parents): these can be translated in an inverse relationship among the variables;

- Part-time availability and informal child-care provision. Referring to this topic, first of all, it has to be made a remark: when we treat the informal child-care we refer to the grandparents' or relatives' role, not to the black form of care provision for taxes evasion purposes. Additionally, it has to be underlined that the maximization process is not related to the possibility of having grandparents itself (unfortunately nobody can choose about his/her life) but on their availability to child-assistance. Turning on the relationship, we expect that in correspondence of an increase in the informal child-care provision, the part-time need will reduce itself, showing a negative linkage among the variables.

Considering the variable towards which maximizing the program, we have opted for the total national aggregate income, that measures the sum of the national aggregate incomes (on its turn, given by the sum of those of each representative firms operating in the Italian context) of each year until the last performed year.

6.6 The testing procedure

In order to proceed with the test, we have to select the Netlogo file from which we want to derive the parameters. Once loaded the parameter ranges from the model interface and maintained only those of interest for the maximization, we have to insert the measure towards which address the procedure (as mentioned above) and to establish the number of steps that we want to be considered. Standing on the fact that during the simulation with Netlogo the results in favor of the part-time availability are plain since from the earlier ***go's*** we limit the steps' amount to a low level (as suggested by the program).

The parameters to be maximized are:

- ***Child-care coverage,*** that represents the availability of child-care services on the area, expressed in percentage terms (100% = full coverage);
- ***Informal Child-care,*** that represents the intensity of the child-care service provided by grandparents or more generally relatives, expressed in percentage terms;
- ***Total part-time availability,*** representing the strength of the increase of the availability with respect to the original situation depicted from the information coming from the LABOR dataset. It ranges from value of 1, in case of a perfect correspondence with the original size of the phenomenon, to value of 2, in case of an increase of 100% with respect the previous cited benchmark.

In defining the Search Method configuration, we choose, as instrument, the GA (genetic algorithm) method, leaving unchanged all the others possible choices. Referring to the fitness evaluation we choose to set the evaluation limit to 300 runs, as suggested by the original setting of Behavior Search.

6.7 Commenting on the results

Before commenting the results we have to specify that we conducted multiple runs of the program: we varied over time the population size (representing the number of subjects, in our case the Netlogo Program, which behavior have to be maximized), the step limits and the combine replicates.

Even these huge changes in the parameter specification, the results can be considered as substantially correspondent between each other.

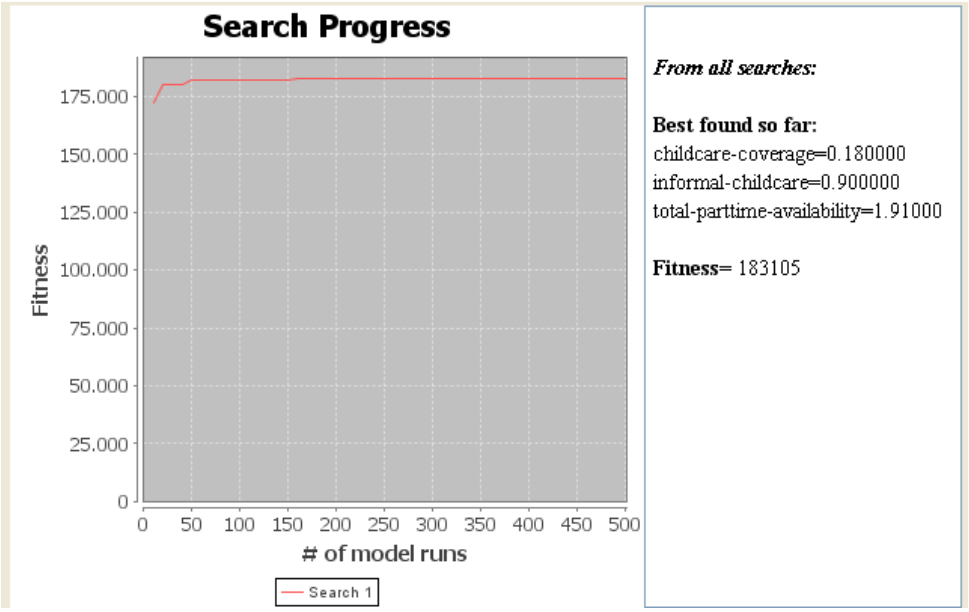


Figure: BehaviorSearch (pop.30,step limits 5)

As the picture shows, we can note, first of all, that the results are obtained as far as the earlier attempts in maximization. This can be translated in the fact that the parameters can be relatively easily combined during the procedure.

Up to the first experiment, conducted on a population size of 30 and considering only 5 as step limit, the coming out results depict an interesting horizon. The best performing level of part-time availability is attested on the 1.91 value: this result confirms our belief about the importance of the role of the part-time provision in determining the wealth aggregate level. More broadly, the model would require with respect to its initial level an increase of the part-time availability around the 100%: this could be

translated in economic evidence, affirming that the more are the part-time available positions, the greater will the wealth on the market.

Evaluating the results of the variables others, we can say that both formal and informal child-care have positive impact (respectively 0.18 and 0.9) in the wealth creation, even if in a very different way. Going more in details, we can say that the inverse correspondence between formal and informal childcare is perfectly confirmed from the evidence of these results. A very high level of informal childcare accompanies a relative low significant value for the formal child-care coverage.

The only relevant result that differs, changing the amount of step limits considered, is the fitness, that represents the maximum level of the variable toward which the maximization took place (in our case the total national aggregate income). Whereas in the first picture its level is attested on 183105 (million of euro), in the case of 10 steps limit considered it is attested on the 671571.

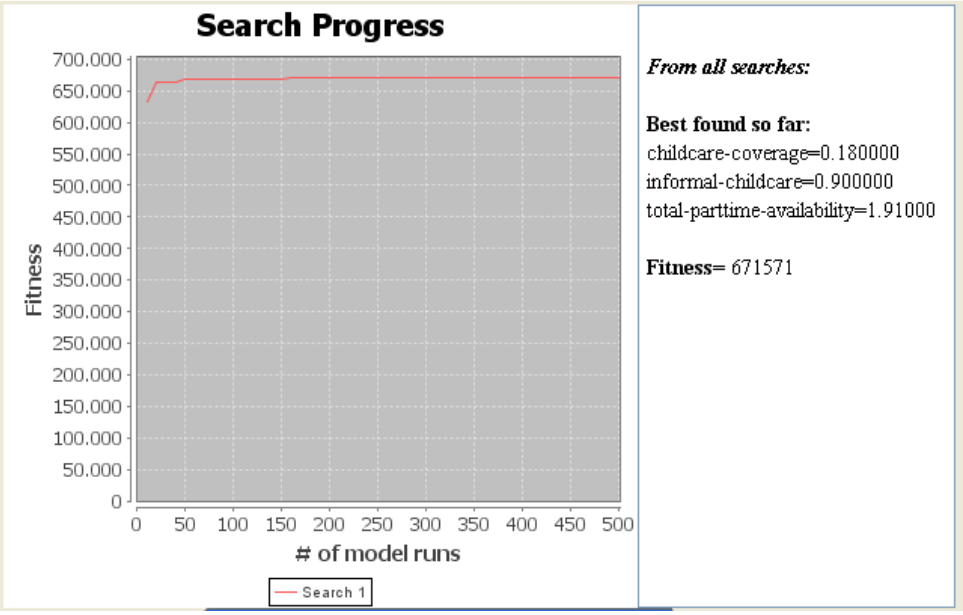


Figure .2: Behaviorsearch (pop.50, step lim. 10)

Independently from the size of results, we can argue that the fitness shows an acceptable value, considering that during the Netlogo running procedure, the level of total national aggregate income is attested on comparable values.

Taking in consideration the possibility of changing the combine replicate variable (that give you the chance for combining the results, arising from the multiple replicate runs of the models, into a single number for the objective function), we choose to consider both the mean and the max instruments.

The first one could be considered as more reliable, even if looking at the second could be interesting for catching the highest possible level achievable of national cumulate aggregate income.

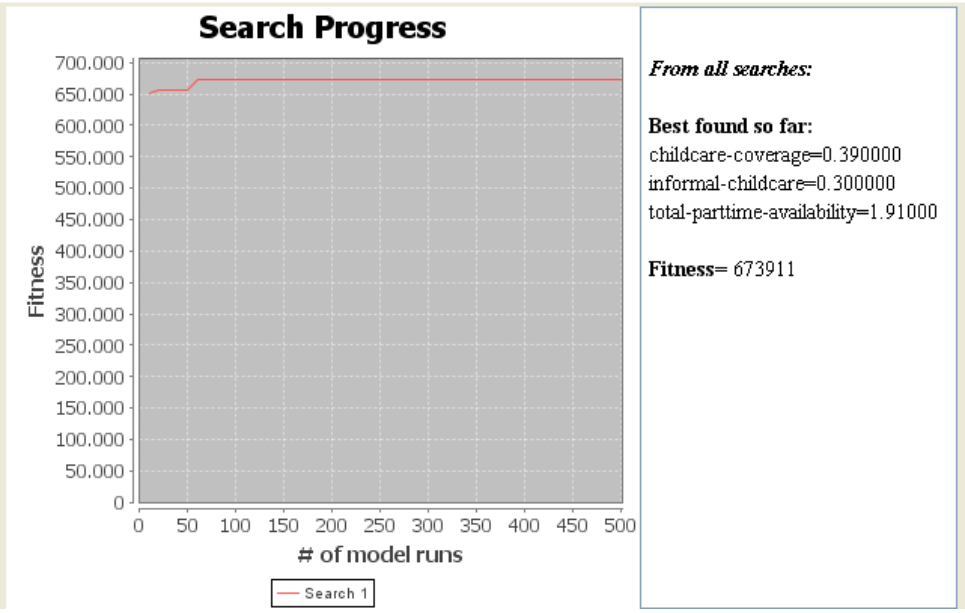


Figure: BehaviorSearch, (pop. 50, step lim. 10, max)

As we foresee, in the case of maximization combine replicate variable, the fitness value is higher if compared with the previous one; probably the highest achievable level that could be reached during this maximization procedure, if we maintain unchanged the other parameters.

Although this interesting outcome, we prefer the results coming from the previous maximization procedure, because of the change in the significance of the other parameters: differently from the evidence of all the other processes, formal and informal child-care, in this case, do not show a univocal inverse relationship (values are attested on 0.39 and 0.3).

Conclusions

In drawing up the conclusions of this document, we can, first of all, underline the consistency of our topic with the economic literature provided until these years.

Many authors underline the importance of both part-time and the other available instruments (such as child benefit, parental leave, formal and informal childcare) in trying to solve the so-called conciliation problem affecting our modern society.

The institutions have an important role and they have to take into account both sociological and juridical context: a perfect knowledge of the actual situation, in fact, will be required in order to introduce useful instruments representing, as in the case of the part-time, no longer a segregation cause but a tool to coordinate domestic and working life.

The juridical context has still to be solved: we can say that also a law system re-organization must be considered an important key element for an increase in the part-time availability in the labour market.

Additionally, to reach a definitive women emancipation, it is adequate to consider also the sociological approach playing a fundamental role in this topic: only when it will completely remove the old vision suggesting an Italian woman only related to her domestic sphere, the emancipation will take place. The modern society has to move from a woman conceived as housewife, to one in career able to manage her time between family and work, thanks to the conciliation instruments availability.

In defining them, other implications have to be taken into account, such as the relationship between grandparents and children: it was proved that, in spending time with their grandchildren, grandparents stay young with respect to their coetaneous who do not take care of their relatives. Furthermore, children spending a lot of time with their grandparents seem to develop additional competences, such as a greater level of independency from the parents, with respect to those growing up exclusively with their parents, especially in the first years of their life.

Considering all these contributions, we decided to search for an innovative instrument able to capture these relationships in an unusual way. We chose an Agent-based

Model allowing us to predict the existence of complex phenomena by introducing rational individuals, assuming that they do what they perceive as their own interest.

In our initial model we proved the consistency of a positive relationship between part-time availability and wealth creation (expressed, in that context, as added value produced by each agent). Although the high reasonableness of the results, a fundamental limit exists: the absence of real data in the entire running of the model.

The second model, instead, was constructed properly in order to solve this limit.

Once manipulated the original dataset coming from the LABORatorio Revelli, we designed a new model allowing us to dress women with real characteristics. A further improvement with respect the previous program is related to the introduction of an additional agent interacting with women: the firms.

Once evaluated the available data, we chose to introduce three representative firms corresponding to the northern, central and southern Italian areas in which all the most relevant differences are gathered together. Also through this simulation, we proved the effective part-time role as a "conciliation" instrument.

However, also in this case, some topics representing a possible further improvement to our computational model can be found. We do not hold a sufficiently detailed dataset allowing us to distinguish not only between North, South and Centre but also among each different firm in a specific industry. The model can be complemented with this additional information, implying a higher amount of agents and, subsequently, a more complex interaction among them. A further improvement could include a more detailed characterization of the female subjects: it is possible to consider their education level, their skills and the related contract typologies. In particular, the last one could provide a measure about the quality of the part-time intervention in preserving women within the labour market. If it is true that a part-time availability increase is able to sustain the wealth produced in a market, it is not so clear where this increase is concentrated, if in low-qualified sector or also in the higher ones.

Capturing this phenomenon, the validity of part-time as conciliation instrument and no longer as a segregation cause (reducing the opportunities for female career, framing her into working position without perspectives) could be finally demonstrated.

Knowing that the relationships among the involved variables are not as obvious as it can appear, we decided to test their validity trough a software tool that explores the

agent-based model in order to maximize it, by using genetic algorithm and other techniques: BehaviorSearch. We conduct multiple experiments, combining different population sizes, step limits. The coming out results are all in favor of an increase in the part-time availability (all the values are centered on the 1.91 value), associated with a formal/ informal child-care provision as a support in the activity, confirming our confidence about the substantial exchangeability between the two different care services. Also taking in consideration the easiness with which the optimization has taken place, probably the maximization procedure could be improved through adding new parameters to be considered (for example the ones, reported above, that we suggest such as a further developments of our model). Additionally there could also be implemented an approach to the maximization other than the genetic algorithm: for example the random search or the mutation hill climber (the alternatives proposed by the program itself).

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Site links

http://behaviorsearch.org/documentation/tutorial.html

http://ccl.northwestern.edu/netlogo/docs/

http://ccl.northwestern.edu/netlogo/faq.html

http://en.wikipedia.org/wiki/Genetic_algorithm

http://en.wikipedia.org/wiki/John_Henry_Holland

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