UNIVERSITÀ DEGLI STUDI DI TORINO

Facoltà di Economia

Corso di Laurea Magistrale in Economics

Tesi di Laurea

Divergences between marginal social and private net product: from Pigou to a simulation model

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Anno Accademico: 2011 – 2012

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Acknowledgements

I am very grateful to my family: my grandpa Athos, my mum Bissi, my dad Franco, my sister Leila and my brother Leonardo, for supporting as well as sopporting me during the writing of this thesis, particularly towards the end, when the sopporting activity has been major.

Also, I am indebted with Professor Pietro Terna for his patience and the indispensable insights and comments he provided me with.

A special thanks to Claudia for the obstacles she always has to face to be beside me.

Introduction

The idea of this thesis slowly arose in my mind. Since the 2007/2009 crisis, I started wondering to which point, and under which conditions, markets are able to direct resources, included human efforts, towards the “best” - or, at least, a not distorted one - allocation of resources. I could see some divergence between individuals' returns to their actions and the social outcome they brought about, thus I was naturally attracted by Pigou's work, and my faith in the possibility of the state to get things right led me to strongly appreciate his work. However, reading the stream of literature that emerged after “The Economics of Welfare”, from the very day after its first editions (e.g. Knight [1924]), through the mid twenty century's “Law and Economics” literature (e.g. Coase [1960]), to the very recent contributions of radical free-market economists (e.g. Colombatto [2011]), I have been swamped by an overwhelming flow of doubts.

What is market all about? What are those institutions able to direct self interest into socially beneficial channels? Further: how deeply can the state invade individuals' sphere of freedom – that is, how far can institutions go beyond the mere enforcement of the law?

These are the questions to which my mind is now headed to: where my study path and the work on this dissertation took me. Of course I do not have the answers, and I will probably not have them in the future. However, asking these questions to myself represents an important step in a line of reasoning that I hope will help me better understand some of the driving forces of our society.

I am inclined to tackle these issues from a purely theoretical standpoint, however I wanted to use the new means that technology offers to make a more complete analysis, to implement an application of the theory without any use of statistical data. Hence, I made use of NetLogo, an agent-based programming language: I tried to put forward a thought experiment, organising reasonable data with the purpose of performing a conceptual test. I did not want to prove any proposition. My work aims at understanding the implications that the economic science provides when some of the simplistic assumptions – first of all, the complete rationality of agents, but also the absence of

interrelations among production functions – are relaxed. Since relaxing assumptions complicates things, I needed a simulation model to keep up with rigorousness.

In the first chapter a review of “The Economics of Welfare” is proposed. Pigou's approach is exposed, following the line of thoughts presented in the fourth edition of his work: starting from a fairly philosophical discussion on his view of economics as a science and his believes about the connections between economic and non economic welfare, the treatment becomes more and more technical. The measurement of the national dividend – an analogous of what we now call gross domestic product – is described and its use as a proxy of economic welfare justified. Then, the concepts of marginal social and private net products are introduced, and their divergence indicated as the cause of failure of self interest in maximising national dividend. Therefore, Pigou holds that the state, through taxes and bounties, should make marginal private net products equal to the marginal outcomes to the society.

Pigou offers a large number of examples in which the divergence occurs, classifying them according to the market structure where they take place and according to the features of the affected parties.

In the second chapter some insights of the literature about externalities are exposed. These are defined as a subset of the cases suggested by Pigou, namely those where marginal products differ because of the modification of one agent's non monetary variables of the utility function, unintentionally made by some other agent.

Mainly, two articles are illustrated and commentated: the first is Knight [1924] which rehabilitates market's ability to reach the same goal as Pigouvian taxes; and the second is Coase [1960] which gives a dramatically different view of the problem, featuring transaction costs as the real roots of market's malfunctioning and property rights reassignment as the way to efficiency. References to other contributions are provided within the treatment of the two principal articles.

In the third chapter the simulation model is proposed. It tries to simulate an economy in which there are both proper externalities (an industry unintentionally affects another industry's production function) and a case of divergence between social and private product due to the purposeful modification of consumers' utility functions by one industry. In this framework the utility maximisation is performed, first with rational agents maximising utility in a non perfect way, as we think they do in real world, and then introducing some sources of “irrationality”, which make agents take their consumption decisions according to criteria other than utilitarian: ideologies and social

norms step in.

In this complex system, we have found that the concept of equilibrium loses most of its attractiveness, in long-run as well as in short-run terms, because of two main reasons: first, shocks are likely to come about before an equilibrium is reached and consequently actions aiming at correcting disequilibria turn out to be useless; second, because of the not perfect maximisation procedure, even when the so-called long-run equilibrium could be reached, it may look different from what could have been guessed. Moreover we point out that in the presence of decision criteria different from utility maximisation, agents tend to downplay the role of their budget constraints.

Chapter 1
The Economics of Welfare

1.1 Welfare and economic welfare

1.1.1 Purposes and characteristics of the economic science

Pigou's view of economics, as he states it in his “The Economics of Welfare”, can be seen as a junction between classical theory and modern “welfare economics”: on the one hand, he rigorously proves his propositions using classical means – and believes, such as the power of pure competition; on the other hand, he opens up the way for building the “welfare state”.

Pigou was a student of Alfred Marshall, in 1908 he succeded him as Professor of Political Economy in the University of Cambridge. Professor Marshall's influence on his pupil can be seen throughout all Pigou's works, ranging from the use of the national dividend as a measure of welfare to the umbrella approach to economic problems, which they both saw as strongly interconnected with all other aspects of life. Economic science is seen as a means through which researchers can help improve the lives of people, and Pigou explicitly states this at the beginning of the book, when he makes an abstract division of human sciences between those the object of which is the sake of knowledge (metaphysics) and those which are useful for what they lead to. The author allows for sciences that have a mixed object – knowledge and practice – but he sees economics as one of the latter type [Pigou, 1932, 28]:

> *It is not wonder, but rather the social enthusiasm which revolts from the sordidness of mean streets and the joylessness of withered lives,*

that is the beginning of economic science.

It is not the economist, though, who decides the practical measures to be taken to promote welfare. His work is mostly theoretical and it is statesmen who "*may build* [practical measures] *upon the work of the economist, just as Marconi, the inventor, built upon the discoveries of Hertz*" [p. 31]

Pigou is aware of the fact that welfare is not made of economic issues only. It is seen by him as a bundle of states of consciousness that form well (or less well)-being, which can be given a degree of intensity though cannot be measured in a cardinal sense. If we conceive welfare in such a broad sense, the task of examinating the causes that make it greater or less is very wide and involves the knowledge of a range of sciences other than economics, such as psychology, sociology, and so on. As human brain is not able to understand as many things as reality is made of, we are forced to make a division – at least a rough delimitation – and to treat the same issue separatedly form the point of view of a number of different sciences.

> *In doing this we are naturally attracted towards that portion of the field in which the methods of science seem likely to work at best advantage. This they can clearly do when there is present something measurable, on which analytical machinery can get a firm grip. The one obvious instrument of measurement available in social life is money. Hence, the range of our inquiry becomes restricted to that part of social welfare that can be brought directly or indirectly into relation with the measuring-rod of money. This part of welfare may be called economic welfare. It is not, indeed, possible to separate it in any rigid way from other parts, for the part which can be brought into relation with a money measure will be different according as we mean by can, "can easily" or "can with mild straining" or "can with violent straining." The outline of our territory is, therefore, necessarily vague.* [p. 31]

1.1.2 Relations between economic and non economic welfare

Let me now underline the fact that, in the light of what has just been said, focusing on the part of welfare that is measurable with money is not such a materialistic approach as it has been said, so long as it is not taken as the final goal. What an economist studies is the economic implications following some cause. The knowledge of them is needed even if we want to go beyond economics, like mathematic knowledge is needed to build a house. A house is not only made of maths: it involves something of an art and some vision of the world, as reflected in the composition and the facilities of the house. But to make the building stand and not collapse, engineers must make proper calculations. In like manner enhancing welfare is not only made of economics. We must take into account also psychological factors and a number of other considerations. But we also, and necessarily, must understand economic implications if welfare is wanted to last.

As Pigou says, there are two kinds of sciences: those studying implications and those collecting facts. In both types something more is needed, something coming from the intellect of the author, that uses implications of the theory to draw conclusions, or that gives meaning to empirical observation. In the case of economics, the materialistic approach is necessary to have conclusions at least about what is measurable with money. But in no way economic welfare represents the final goal of our inquiry. However, a problem comes up at this point. After economists show that something improves economic welfare, nothing guarantees that total welfare will be enhanced too. There may be some of the other "states of consciousness" which are altered in an opposite way, canceling out the positive effect of economic improvement. Pigou identifies two groups of "environmental causes" linked to economics that affect non economic welfare. These are the way income is earned, and the way income is spent.

As regards to the first group, we can really understand from Pigou's words how clear it was from the beginning of the industrial expansion of the Western world the danger of this kind of social organisation.

> *The human relations that arise out of industrial relations are also relevant. In the great cooperative movement, for example, there is a non-economic side at least as important as the economic. Whereas in*

> *the organisation of ordinary competitive industry opposition of interest, both as between competing sellers and as between sellers and buyers, necessarily stands in the forefront, and results at times in trickery and a sense of mutual suspicion, in a co-operative organisation unity of interest is paramount. This circumstance has its influence on the general tone of life.* [p. 34]

In a more modern contest, labour reforms, made in order to try to stimulate the economy through a more dynamic labour market, affect non-economic welfare. These reforms are to find a balance between the motive of enhancing economic welfare through an increase of the gross national product with the motive of enhancing total welfare as represented by the protection of the worker.

The second group regards the way income is spent. There are some goods the consumption of which is more desirable than others': building a museum boosts total welfare more than building a pub does. This is because the effect of consumption of goods is not limited to the immediate satisfaction we receive from it, but it entails a change in the other components of well-being: cognitions, emotions and desires.

Pigou solves the problem of possible conflicting effects of economic causes on total welfare with a presumption: unless there is evidence of the contrary, any cause improving economic welfare is reckoned to have a positive effect on total welfare as well, though not necessarily of the same magnitude. If any one believes this is not true for some specific case, the burden of the proof should fall on who wants to break the presumption. This sends us back to when I said that the materialistic approach is needed: if we have no reasons to think that a cause enhancing economic welfare may negatively affect total welfare, then we are allowed to proceede as if there were actually no collateral effects, and we can maximise the economic utility. Materialistic considerations have the main role here. But this does not mean that economists do not have to consider non-economic results suh as social issues. It means that, when no other issues are raised, maximisation of economic welfare is the best option. Moreover, I would add, also when issues other than economics are raised, the materialistic approach, leading to an efficient use of resources, is indispensable. The decision taken will not be that maximising economic welfare, because those other considerations are in act, but through the use of economic tools a higher level of efficiency, constrained by taking into account other factors, will be reached.

A final point, connected to the last one, is considered by the author. The overall result of economic actions at least partially depends on the cultural framework in which the cause takes place. Actions are both influenced by the environment, and they affect the environment in turn. This issue recalls the dispute between orthodox economists, who treat agents as economic men always behaving in the same rational way, regardless of culture, and structuralist and institutional economists, who claim that human actions are actually modified by the characteristics of the environment, such as institutions, religion and culture. Pigou's stand, which is actually the one proposed by John Stuart Mill [1843, 488-491], is that institutional characteristics matter, but it would be too intricate to account for them in building the economic model. Thus, the economic model should be erected first, holding all other characteristics constant. Only after that differences in social environment can be allowed for. Pigou adds that, in developed nations with a stabilised culture such as Western Europe countries, the ceteris paribus condition is a good approximation of reality. He could certainly not guess that industrial development could have led society to change its values in such a dramatic way as consumism has done.

1.2 Measurement of economic welfare

1.2.1 Satisfaction and desiredness

After having elucidated the relationships between economics and the rest of human knowledge and after having clarified the reasons why focusing on this science not necessarily implies materialism, let us now restrict our attention on the analitycal tools that render our approach rigorous.

Economic welfare is defined as those satisfactions and dissatisfactions that can be sized with the measuring-rod of money. However, the direct measurement of them could be done only after the cause has taken place, that is, only after the good or bad has been

consumed. Since we want to understand *a priori* what is the increase of welfare that an economic cause would bring about, we are forced to abandon the direct measurement of satisfactions and substitute them with the "desirednesses" related to them. That is to say, we proxy the satisfaction consequent to the consumption of a good with the intensity with which that good is desired. This indexation would be out of question if the ratio of the intensities of desire of a man for two goods were proportional to the ratio of the economic satisfactions caused to him by those goods. It is not always true though, first of all because of the distorted expectations that people often have about the satisfaction they can obtain from things. However, the wedge between willingness for and pleasure deriving from a thing is usually small when the good in question is something of every day life, because the satisfaction deriving from it has been experienced many times and its desiredness has been accordingly adjusted. In like manner, also more unusual things can be expected to be desired in a proportion that is not very far from the economic pleasure that follow them: experience is likely to correct for possible misperceptions.

1.2.2 Subjective discount rate

The most important shortcoming of indexing satisfacion through willingness arises when we consider the attitude of people towards the future. The point is that equal satisfactions are desired with different intensities accoding to the time in which they will occur. There exists a subjective discount rate that makes the desiredness of satisfactions occuring far in the future less intense than the desiredness of satisfactions of the same magnitude occurring in the nearer future.

> *This reveals a far-reaching economic disharmony. For it implies that people distribute their resources between the present, the near future and the remote future on the basis of a wholly irrational preference. When they have a choice between two satisfactions, they will not necessarily choose the larger of the two, but will often devote themselves to producing or obtaining a small one now in preference to*

a much larger one some years hence. [p. 41]

Pigou defines the telescopic faculty as irrational, and in fact we can clearly see that it leads to enjoying a minor degree of satisfaction than what could have been enjoyed had the subjective discount rate been zero. The author rules out the risk about the future to focus on the deterministic valuation of satisfactions of equal intensities but different times of realization, and he thus compares two "certain" things occurring at different points in time. However, in my view, there is nothing certain but death, and it is completely rational to assign greater weight to satisfactions that can be enjoyed now, since they are the only ones completely certain. Hence, the subjective discount rate could be seen as a "risk of death" ponderation. Is it true that, if human being were immortal, the telescopic faculty would still exist, due to the fact that things today are felt better than things tomorrow? We could guess it would be smaller, but this does not convince me since, if we were immortal, then probably our cognition of time would be different (if immortals have a notion of time at all!). Hence, I would not say that the preference over equal satisfaction nearer in the future is irrational. It leads to counterintuitive and undesirable results, in that a smaller satisfaction today is preferred to a much bigger satisfaction ten years hence, but there is nothing irrational in it – at least, nothing irrational in a human sense of rationality, and not even in the utility-maximising sense that economists usually mean.

Pigou only considers the death issue talking about investment, and highlights the possibility that the fruits of such investments may be enjoyed by successors of the investor. That is the case of long term investments, for which the telescopic sight of future fruits, regarding not investor's own satisfaction but that of someone else, can have a very high discount rate. The presence of stock-exchange markets partly overcomes this issue, since dividend yielding assets can be sold for a price that includes future income flows deriving from them. However, there are several cases of investments in which a monetary dividend does not exist (think of "*planting a forest or undertaking drainage development on one's own estate*" [p. 42]) and for which the hyperbolic discount, powered by the fact that the investor will not live enough to take up all advantages of his investment, constitutes a high obstacle to those undertakings.

Thus,

The practical way in which these discrepancies between desire and

> *satisfaction work themselves out to the injury of economic welfare is by checking the creation of new capital and encouraging people to use up existing capital to such a degree that larger future advantages are sacrificed for smaller present ones.* [p. 42]

The author lists a great number of situations in which this occurs, summarisable in the wasteful use of natural resources such as coal, fish and fertile soil, and suggests that Government, being the guarantee and the protector of future generations, should counter the egoistic tendency through incentives to saving, in particular through fiscal facilitation of savings. Pigou states that Government should not counteract the minor valuation of future satisfaction so much that it is aligned to present satisfaction, but in a sufficient degree so as to allow natural resources preservation.
However, fairness considerations row against a tax system built in such a way, and Pigou is aware of that: facilitation of savings means less progressive taxation since who is able to save is usually more wealthy than who cannot.

1.3 The national dividend

1.3.1 Measurement of national dividend

The relation so far described between welfare and economic welfare is, according to Pigou, parallel to the relation existing between general income and that part of it that can be measured in money.
Thus, it is recognised that "income" is not only a monetary (or real, in terms of goods) return, but includes all those effects that enhance well-being. It is important to notice it because in recent times not very wide attention is paid to consequences that are not measurable in money – as it has already been said talking about welfare. When classical

welfare economists proposed their approach, they precisely set the conditions under which the materialistic analysis worked, and, even though they concluded that economists could proceed ignoring non monetizable effects, they still had well fixed in mind the fact that such effects have importance: they put them on a side, not just forget them.

The two concepts of economic welfare and national dividend are thus co-ordinate. As economic welfare is not rigidly separable from its total, so national dividend cannot be taken apart with rigorous limits. This is so because what can be put into relation, directly or indirectly, with money, depends, as already said, on what we mean by "can" – can easily or less easily. The two concepts are also connected because economic causes mainly effect economic welfare indirectly, acting through the national dividend: firstly, if the portion of the divident accruing to the poor is not diminished, then any increase in its size augments national economic welfare; secondly, when the size of national divident is unchanged, then any redistribution in favour to the poor enhances aggregate economic welfare. Before considering the details of this statements, let us define precisely what we are talking about.

The national dividend is made of goods and services produced by the community in a period of time, plus those received from abroad – notice that we are talking about real quantities. It is a stream, not a stock and it includes the value added in a certain time through production, so that a good or a service that has been used to produce some other good or service should not be counted if we already considered the final product. Ideally, the perfect calculation would be one including the whole flow of goods and services produced, even though not exchanged for money, including volounteer labour, home producing and so on, but measuring goods not sold would be practically impossible, and a statistical inference would be unreliable. Pigou then chooses to count only goods bought, adding to them the services rendered by inhabitating own houses.

1.3.1.1 Consumed versus produced national dividend

However, a question raises: goods bought by whom? There are two possible ways available: that sustained by Marshall, whose method includes in the calculation goods bought by any economic unit, firm or consumer, always avoiding double-counting; and that proposed by Fisher, for whom only goods sold to consumers should be part of the

dividend.

These two views are both correct, but the choice over one of them, since they highlight different abilities of a community, is related to the goal of the inquiry for which they are used. To the question as to which one should be used in our analysis, Pigou states:

> *The answer to it, as I conceive the matter, turns upon the purpose for which we intend the conception to be used. If we are interested in the comparative amounts of economic welfare which a community obtains over a long series of years, and are looking for an objective index with which this series of amounts can be suitably correlated, then, no doubt, the conception which I have attributed to Professor Fisher's hypothetical follower is the proper one. It is also much more relevant than the other when we are considering how much a country is able to provide over a limited number of years for the conduct of a war; because, for this purpose, we want to know what is the utmost amount that can be squeezed out and "consumed," and we do not premise that capital must be maintained intact. The major part of this volume, however, is concerned, not with war, but with peace, and not with measurement, but with causation.* [p. 47]

The point is that, when an economic cause takes place, we want to measure by how much economic welfare is increased, not only for the year in which the cause occurs, but over the whole period in which it makes effects. Then, considering also goods bought by firms we take account of those durable goods that will contribute to future production (corresponding to future improved welfare) while with Fisher's method we should count all future national dividends that will be affected by the cause in consideration – also dividends that are not yet occurred at the moment of the implementation of the cause, so that we could only make a posteriori considerations. Then, Marshall's definition of national divident is the best instrument for our purposes, in that it incorporates future consumption reflecting future changes in economic welfare.

The adoption of this method requires attention to the issue of double-counting. As already said, all intermediate goods and all services rendered by other firms should not be calculated, because they are contained in the value of final goods. However, this is not all. Counting the machineries used to produce the final goods, even though is required to get the marshallian estimate of future consumption, would represent double

counting if no correction were made, since the cost of using them is incorporated in the value of the goods produced through them and sold in the current year. That is to say, there would be double counting of the value added by those machineries to the goods sold in the year for which the calculation is made, while there would not be double-counting of the value they will produce in subsequent years. A natural correction to this problem is subtracting from national dividend the yearly depreciation of durable goods employed in the production of goods that have been sold in the year for which the calculation is made. It can be easily seen that, deducting intermediate goods and depreciation, what is left is the value added to the materials in the course of manifacture, which represents the fund from which wages, taxes, profits and all similar charges have to be defrayed.[1]

Seen in this way, national dividend could seem to be exactly equal to total income perceived by the community. However, in general this is not true, since summing up all incomes received by citizens would constitute double counting of gifts (for instances allowances conceded by parents to their children) or whatever is given against something that is not accounted for in the national dividend. Hence, all such things as war pensions, income received on state loans used unproductively, and so on, should be subtracted from national income to make it equal to national dividend.

1.3.2 National dividend increases when economic welfare increases

As economic welfare is related to the size of national dividend, so changes in economic welfare are related to changes in the size of national dividend. The problem of measuring alterations of the dimension of national income derives primarily from the fact that, when we have to compare two dividends, for example produced in two different periods of time, dissimilarities in their composition make it difficult to say whether one is greater than the other, because what we are measuring is a stream of goods, not the money value of it. Moreover, since we are interested in the national

1 The British Census of production of 1907, CF 6320, from which this phrase has been taken, did not subtract depraciation, hence a reformulation of the sentence has been made to allow for this difference.

dividend in that it causes economic satisfaction, another problem is the fact that variations of tastes could alter the relation between a certain composition of the dividend and the economic welfare associated to it. However, since national dividend is an objective thing, "*we should naturally wish, if we were able, to define changes in the size of it by reference to some objective physical unit, and without any regard to people's attitude of mind towards the several items contained in it.*" [p. 57]

Finally, a third issue is that in the two periods the distribution of purchasing power among the community may be varied, so that the valuation of the two dividends may differ even though their composition remains unchanged.

Pigou proposes a method to compare two dividends that offers a remedy to all of these problems:

> *Considering a single individual whose tastes are taken as fixed, we say that his dividend in period II. is greater than in period I. if the items that are added to it in period II. are items that he wants more than the items that are taken away from it in period II. Passing to a group of persons (of given numbers), whose tastes are taken as fixed and among whom the distribution of purchasing power is also taken as fixed, we say that the dividend in period II. is greater than in period I. if the items that are added to it in period II. are items to conserve which they would be willing to give more money than they would be willing to give to conserve the items that are taken away from it in period II. This definition is free from ambiguity. However the technique of production has altered,— though it has become more costly to make one thing and less costly to make another, though it has become possible to make some entirely new things and at the same time impossible to make some things that used to be made before,—it can yield one conclusion, and one only, as to the effect on the size of the national dividend of any change in its content that may have taken place*. [p. 57]

Using this method we turn the concept of dividend, which was so far conceived in real terms, into a money measure, but it has to be noticed that Pigou only introduces the money value in relative terms, while considering the change in the size of it.

According to the method thus specified, the procedure would be that of summing up all consumer surpluses deriving from each kind of commodity contained in each of the two

dividends. The change in the size would be the excess – or the defeat – of the sum obtained for one situation over the sum relative to the other situation. Although this measure would be the nearest approximation of what we are looking for, it is practically impossible because it involves at least the knowledge of the elasticities of the demand of every component of the dividend, or even the whole shape of the demand functions. What is available is only quantities and prices, and we are forced to use these data in building a measure that is as close to the definition put forward by Pigou as possible.

> *Hence, the utmost we can hope for is a measure which will be independent of what the state of tastes and distribution actually is in either of the periods to be compared, but which will always increase when the content of the dividend has changed in such a way that economic welfare (as measured in money) would be increased whatever the state of tastes and distribution, provided only that this was the same in both periods. Even if the whole of the data about quantities and prices were accessible to us, it would be impossible to construct a measure, based on these data alone, conforming more closely than this to our definition; and, plainly, this degree of conformity is very incomplete.* [p.61]

Again, the concept of national dividend is linked to that of economic welfare – even though that of consumers only: since we cannot measure changes in the size of national dividend in the precise way as its definition would require, the approximation needs to be tied to the purpose of the analysis, and this means defining an increase in the national dividend as a change that brings about an economic satisfaction (of consumers, measured in money) that is greater than the satisfaction obtained in the first period. It is not necessary, Pigou says, that if the change in economic satisfaction is A, then the measure of the dividend should change by A as well, and that if the change in economic welfare is 2A, then the size of the dividend should adjust by 2A either. It is only needed a measure that shows an increase whenever economic welfare increases, and vice versa.
A final, very important issue, must be highlighted. We have constructed the measure of national dividend in such a way that it increases whenever economic welfare, as measured in terms of the monetary satisfaction that *consumers* assign to the bundle of goods contained in the dividend, increases (provided the share accruing to the poor has

not diminished). However, there may be cases in which economic welfare, arising from factors other than aggregate demands – other than consumers' satisfaction – decreases when the dividend increases. To complete the definition Pigou says that growth in the size of national income (measured through the greater satisfaction that consumers enjoy) involves an increase of (total) economic welfare if the satisfaction deriving from the major national dividend is greater than the dissatisfaction created to produce it – typically, to workers, but also to the community, in the form of pollution, for example.

1.3.3 Economic welfare changes with the distribution of the dividend

Considering a dividend of a given size, the distribution of it among members of the society having different wealth matters in the relation between that dividend and economic welfare. Even though such distribution can change for reasons other than a redistribution of income, for example because the cost of production of goods mostly consumed by the poor diminishes while the cost of producing luxury goods increases, yet this is the most common and relevant way in which the dispersion of the dividend affects economic welfare.

The law of diminishing utility states that the satisfaction an individual derives from the consumption of a good decreases as the quantity consumed rises. People with a greater purchasing power obtain less satisfaction than poorer people from their marginal expenditures. Hence, a transfer of income from the former to the latter, keeping the overall size of the dividend unchanged, will increase aggregate economic welfare. Moreover, Pigou states that a portion of the satisfaction individuals get from their income arises not only from the absolute size of their income but also from the relative magnitude of it with respect to other people. Then, diminishing the incomes of the rich altogether would decrease their utility by less than what would be if only one rich person's income were to be lessened. For this reason, a redistribution in favor to the poor made in such a way as to keep unaltered the relative satisfaction of the rich would power the result of the law of diminishing utility because of a minor loss of economic welfare of the rich.

1.4 Marginal social and private net products

So far we have been talking about the dividend as an aggregate flow of goods produced – with the corrections mentioned to highlight the value added only– in a certain period of time. We shall now focus on another kind of flow: the marginal net product, which links the use of a small increment of resources in a particular utilisation to the value it adds to the total product.

The marginal net product of a flow of resources in a particlar activity is the additional product that a small increment of the flow permits to obtain, after having reorganised all inputs involved in production in such a way as to maximise the profit deriving from the new set of resources, inclusive of the increment. The marginal product conceived in this way is parallel to the long run maximisation problem in firm's theory: the product of the addition of a unit of resources in this sense is not the increase in output given by the grater use of that resource keeping other inputs constant – short run maximisation in firm's theory – but that obtained after all other resources are reallocated in the most efficient way. The two products to be confronted, the starting one and that consequent to the increment, are both achieved with the optimal allocation of inputs relative to each one, and the marginal product is the difference between the two.

Pigou introduces a distiction between marginal social and private net product. The latter is simply the additional output accruing to the person who made the investment: it is the marginal product as conceived in the long run maximisation problem in firm's theory. The marginal social net product of a factor of production is instead the additional output for the whole society, "*no matter to whom any part of this product may accrue.*" [p. 10]

Even though the word "social" may make one think of including some psychical consequences of the investment, such as changes in tastes induced upon consumers, this is not what Pigou meant. As he previously stated in the discussion on measurement of national dividend there are no data to make judgements on changes in tastes: all we can use are prices and quantities. The concept of marginal social net product must then be conceived as the *additional physical things or objective services* deriving from the increment of resources and accruing to any one.

The value of marginal social and private net products of a given output are simply the product of the additional unit of resources employed multiplied by the price that would

be prevalent if that output were to be produced.

Let me now make a digression. Adam Smith in his conception of the invisible hand conceived the free play of self interest as being beneficial under a system of enforced law that estabilishes up to which point self interest can act freely. Hence, all such things as theft, fraud and cheat are forbidden: self interest can act in a framework given by ever-evolving social institutions such as Property or the territorial State. Pigou says:

> *This adjustment of institutions to the end of directing self-interest into beneficial channels has been carried out in considerable detail. But even in the most advanced States there are failures and imperfections. We are not here concerned with those deficiencies of organisation which sometimes cause higher non-economic interests to be sacrificed to less important economic interests. Over and above these, there are many obstacles that prevent a community's resources from being distributed among different uses or occupations in the most effective way. The study of these constitutes our present problem* [p. 106]

The theory of the invisible hand shows us that under some conditions, including some social institutions, private interest leads to the most efficient allocation of resources, that corresponds to the allocation in which marginal private products of all investments are equal. The Pigouvian introduction of the concept of social product has allowed for some extrernal effects of private actions, not captured by the market, not channelled by institutions. These effects cause divergences between social and private products, so that self interest, even though leading to maximise the private product accruing to the parties involved in the contract, does not maximise social product in general; hence, it does not maximise the national dividend. What should be equalised among all different uses is marginal *social* product, because only this allocation can give the maximum social output. Thus, if we were able to level out the divergences between individual and collective marginal products (also called external economies), the pursuing of self interest would automatically distribute resources among uses in the best social way.

1.4.1 Hindrances to equality of private returns

Before analysing the reasons why social and private products may differ, it is necessary to clarify that in some cases marginal private net products are not equalised in all uses although self interest is left free of acting. This is so because sometimes obstacles to movements of resources from an occupation to another are present: these hindrances may be classified into three main classes.

The first case arises when there is imperfect knowledge about the return on investments: if the investor is not able to know for sure what the exact yields of different uses of his resources will be, it follows that his decision, unless his guess has been very lucky, cannot lead to perfect equality of returns. Since returns are often uncertain, this case is very important, and can seldom be removed altogether. One of the institutions that partially and indirectly tries to limit the problem is bancrupcy, through the elimination of people who choose bad investments.

Pigou finds the development of professional financiers a good improvement in this respect because their specialist job is to select more worthy opportunities of investment, and in so doing they can rely on more information than individual enterpreurs. Their activity of monitoring different markets can diminish the lack of information that an ordinary individual considering alternatives to his investments would suffer. However, professional financiers have the incentive to use the better information for their own interest, pushing investments that are profitable for themselves and not necessarily so for the fund-owner. Public financial regulation is then needed to cope with this possibility.

The second reason why perfect equalisation of returns cannot take place is the cost of movement of resources from some use to another. Evidently, if the cost of moving a unit of input from one occupation to a more efficient one is higher than the saving that such reallocation would entail, then no change will be made and returns will be different by, at most, the value of the costs of movement.

Pigou lingers over the fact that equality of marginal products can be hampered by the opportunity that units of resources that can be moved from an investment to another are not small or are compounded of two factors in a fixed proportion. In this case the infinitesimal analysis according to which the product of small increments must be the

same in all uses cannot be put in practice.

The third and last motive of inequality of marginal products over different uses is represented by the adjustments following variations in demand from some good – or firm – to another good – or firm: usually, some time elapses before resources are reallocated to face the shift, and in the meanwhile the divergence between the marginal products of the resources in the two sectors or firms causes the returns to level out. In the presence of cyclical fluctuations it may well happen that equality of returns never occurs.

Notwithstanding these motives why perfect equality of marginal private products is unlikely to be completely reached, there is still a tendence to get them even: the considerations of this paragraph make the analysis more realistic, they do not mine it at all.

Lastly, it must be noticed that in some cases the intervention of the state can diminish costs of movement or improve knowledge, but the cost of state action has to be considered in the calculation of the social fruits of such an intervention: it may only transfer a cost from an individual to the community (as in the case of bounties designed to reduce costs of movement). In some other cases the state can avoid hindrances with no costs, through regulation (in the previous example, financial regulation): in this case we cannot talk about interference of the state in the economy, but on the contrary it is an enforcement of the rules on which market is based, the enforcement of those institutions that channel self interest into socially desirable activities.

1.5 Divergences between social and private products

I will start this section with Pigou's words, and the rest of it will exactly follow the train of thought in the same order as the Professor laid it down in his chapter IX of Part II of "The Economics of Welfare".

> *In general industrialists are interested, not in the social, but only in the private, net product of their operations. Subject to what was said in* [last paragraph] *about costs of movement, self-interest will tend to bring about equality in the values of the marginal private net products of resources invested in different ways. But it will not tend to bring about equality in the values of the marginal social net products except when marginal private net product and marginal social net product are identical. When there is a divergence between these two sorts of marginal net products, self-interest will not, therefore, tend to make the national dividend a maximum* [p. 132]

Professor Pigou, to try to make a clear analysis of the complexity in which these divergences can take place, deals with the issue by separating three frameworks that can happen to be the environment in which the agents are immersed. These are pure competition, monopolistic competition and bilateral monopoly.

1.5.1 Pure competition

In the pure competition case, the divergence between social and private net product can occur in different ways, according to who is the person affected by the external economy, namely: the owners of durable instruments of production used by the agent causing the externality; persons who are not producers of the commodity in which the investor is investing (the most general case in which the affected party is not involved in

the contract nor in the productive activity related to the one causing the externality); persons who are producers of the same commodity.

1.5.1.1 Effects on owners of unperishable goods

Let us first tackle the first class of cases. These arise whenever the ownership of some unperishable good, typically factors of production, is separated from the tenancy. Here, in the absence of particular clauses in the contract (that is, if the contract schedules the return of the good as it occurs to be at the end of the tenancy) there is no incentive for the user to increase, or at least to maintain the value of the instrument especially at the very end of the contract term: the leasing party would gain by using the factor as much as he can to extract the greater product from it, even though by doing so its yield could be damaged for the future, just because the tenant will not suffer from this damage. Thus, the private net product of using the factor by the tenant is greater than the social net product, in that he receives from the factor something he does not pay for: the wearing. In like manner, the private net product accruing to the owner falls short of the social product.

In the real word this kind of external economy is easily overcome by the law. Years of evolving legal systems have led to the design of contracts that, taking account of the divergence between owner's and leaser's interests, design an incentive structure able to level the discrepancy. The most common solution is the enforcement of compensation schemes by which the tenant is compelled to pay for the injuries made on the durable good at the end of the lease, or on the contrary is compensated for the improvements apported and not enjoyed by him because of the end of the contract.

As previously noted, self interest needs to be channelled by some institutions in order for it to be beneficial to the community. The kind of divergence between social and private sake that arises in the case just described does not need for government interference. Government intervenes in the sense that it assigns and enforces property rights, but the market is left free of acting, based on those rights. Adam Smith's so called “invisible hand” in this sense is not really invisible. There would be an external effect if the compensation scheme were not present but since it is possible for a contract to include such otherwise external effects, we conclude that in this case the market, acting upon a proper framework of enforced law (the “invisible hand”), can lead to the socially

most desirable outcome.

1.5.1.2 Effects on third parties

The second case (probably the most important from the point of view of externality problem) of divergence between social and private net product that can occur under simple competition is one in which

> [...] *one person A, in the course of rendering some service, for which payment is made, to a second person B, incidentally also renders services or disservices to other persons (not producers of like services), of such a sort that payment cannot be exacted from the benefited parties or compensation enforced on behalf of the injured parties.* [p. 138]

Pigou at this point clarifies that this kind of external effect may well be non monetisable: the dinstinction made at the beginning between desires and satisfactions that can or cannot be sized with the measuring-rod of money is important to identify strictly economic issues, and to infer sure solutions regarding pure economics, to be integrated later by other considerations. However, it would be pedantic to strictly apply the definition here, where the heart of the problem remains unchanged even overlooking that dinstinction.

The Professor cites a number of examples in which private net product falls short of the social one: cases in which payment cannot be exacted from third benefited parties because, for instance, of the non excludability of the good in question, or because of high costs that such exaction would entail. These examples are: public parks; afforestation practices; devices designed to prevent the emission of smoke from factories; scientific research.
Examples of social product falling short of the private are instead: the building of a factory in a residential quarter of a city in such wise that it ruins the amenities that used to increase the value of houses; erecting buildings in already crowded centers; production and sale of intoxicants; the working of women in factories, which is

associated to increased mortality among their children.

Unlike in the case of the tenancy, here payment cannot be exacted and compensation cannot be granted simply because the affected or benefited person is not part of the contract that causes the externality. Thus, there cannot be estabilished a system of contract enforcement – with, for instance, compensation shemes – able to avoid such external economies and consequently the market cannot attain the best social solution. There is then room for state intervention: *if it so chooses*, the state can remove the divergence between private and social product by *extraordinary encouragements* or *extraordinary restraints* [p.143, Pigou uses Adam Smith's words], the most obvious of which are taxes and bounties. These are substitutes of penalties and compensations: being not able to fix directly the liability rules according to which private parties can bargain, the state can impose a kind of indirect compensation scheme (passing through the authority of the community).

The fact that the state can choose whether or not to put the tax or the subsidy makes it clear that it is a political decision. However, it could be said that even in the previous case of the tenancy law the state could well decide not to enforce the compensation scheme. Is it a political decision in the same way? The point is: what is considered to be deserving protection and what is not? There are some things that are no doubt considered by everyone worth of protection: in the tenancy law, what is looked after is the accumulation of capital. This is not a political issue: it would be difficul to find some politician who advertises waste! Moreover in that case the compensation scheme is the easiest and most efficient way of reaching the goal (it is easy since the persons involved are all parties of a contract). Hence, it is not a political decision whether or not to enforce the compensation scheme in that case: it is the obvious solution agreed upon by everyone (it suffices to say that actual italian Codice Civile has been written by fascists). There are other things, instead, that are liable of political discussion because some ideology would sustain the protection of them while some other would not. Moreover, even though it were held by every different ideology that some cause is worth protection, there may be conflict in the ranking of the means to reach the goal.

In conclusion, whenever some external effect is conceded to (imposed on) a third party from (to) which no payment (no compensation) can be exacted (given), the market cannot maximise social net product because the law which it is based on is not able to set private product equal to social product. The inefficiency thus arising can be mitigated by state intervention mostly in the form of taxes and bounties, but also, in extreme cases, in

the form of autoritative control (Pigou sees as an extreme case that of poor mothers working to the injury of their children: his solution is prohibition of poor women working plus a subsidy to substitute their forgone wage). The government can choose whether to implement a corrective policy if it considers the lost product to be worth protection.

There are several examples of policies correcting external effects in “The Economics of Welfare”. For the case of negative externalities (causes imposing costs on third parties) the most elucidative example is the industry producing and distributing alcoholic drinks. The diffusion of the consumption of them is positively correlated with the need for police and prisons (I would add medical services, since nowadays free health care is provided by the state in Italy), hence this sector is consistently taxed.
On the other hand a policy facing a positive externality (positive effect on third parties) is represented by public universities, which, through the promotion of scientific research, enhance and spread knowledge available to the whole mankind.

The examples so far exposed refer to situations in which a contract has some effect on third parties in terms of additional or lessened quantity of some good enjoyed by them. There is a further case to be examined, which connects us with the final part of this thesis. It is the following: the satisfaction people derive from a given quantity of a good can change; it may be altered, for instance, as a consequence of the consumption by other people. For example, the great diffusion of some sorts of good can enhance the satisfaction that people derive from it (Pigou's example: top-hats). Other kinds of commodities are instead enjoyed with a greater degree when no one else has got them: for instance, diamonds. Thus, not only may a clause increase or decrease the quantity of some good that persons not involved in the contract can use, but also it can change their tastes. In “The Economics of Welfare” this opportunity is accounted for, but it is put on a side because, according to Pigou, this effect on tastes is negligible since the greater part of satisfaction derives from the pure consumption of goods. In recent times, when necessity goods are not missing to anyone and superfluous ones are spread over, this opportunity has a greater importance.

1.5.1.3 Effects on producers of the same commodity

The third and last case of external effects in a perfectly competitive framework is one in which the damage or the benefit is imposed on producers of the same commodity as the generator of such effects. In particular, the externality in this case occurs when the entry of new firms into the industry causes a change in the production function of the other firms in the industry. The marginal analysis helps approach this issue: let us review the concept.

The marginal product is the change of output given by an increment of resources, after all other units are reorganised in the most economic way. Thus, the product of all other units changes. If they belong to the investor of the marginal unit he will take into account the effect on them; however, if the other units belong to someone else a divergence between the marginal product of the whole industry and the marginal product accounted for by the marginal investor arises, and production will be led to the point where marginal private net product, but not the marginal social one, equals marginal cost: economic welfare is not maximised.

It becomes then relevant the dinstinction between increasing and decreasing productivity: where the addition of resources to an occupation increases the product yielded by all other resources invested in the industry, a postive exernality derives; where marginal product is decreasing instead, the addition causes a negative effect on other units.

1.5.1.3.1 Increasing, decreasing and constant costs

Traditionally, the literature has been talking about increasing, decreasing and constant costs or decreasing, increasing and constant returns. The two concepts are reciprocal to one another since in competitive framework the price is exogenous to the firm and fixed. However, it is not clear whether they refer to average or marginal values. This creates ambiguity because if a cost function is first decreasing then increasing, there must be a region in which marginal cost is increasing while average cost is decreasing, hence referring to unspecified costs is not precise enough. Pigou, to free from equivocals, puts forward the concept of increasing, decreasing or constant supply prices, occurring when

the price that leaves the equilibrium firm in equilibrium increases, decreases or is constant with an expansion of the output of the industry as a whole (regardless of the effect on the size of the equilibrium firm). Since in equilibrium price is equal to both marginal and average cost, this definition allows us to procede without uncertainty. Before going on and seeing whether a connection between this concept and external effects exists, some more clarifications have to be made.

When the output of an industry increases, the cost per unit of output can change because of changes in the price of inputs or because a different quantity of resources is needed to obtain a unit of output (or both). From the point of view of the community changes in prices not due to improved or worsened conditions of production are irrelevant because they only mean a transference of resources from a sector to another. Hence, if the rise of output changes the price of its inputs, not because of an improved production of them, and consequently the cost per unit of output increases even though it has been obtained with the same quantity of inputs, then, from the standpoint of the community, cost has not changed: supply price is constant. The only thing that affects supply prices form the standpoint of the community is the fact that, when the size of the industry increases, the production function of the equilibrium firm may change in such a way that a greater or a minor *quantity of inputs* is needed to obtain a unit of output.

From the point of view of the industry, instead, the supply price alters with increases in output both because of changes in input prices and because of modified production functions. We shall call this relation "increasing, decreasing or constant supply prices *simpliciter*", to separate it from "increasing, decreasing or constant supply prices for the community".

Now, what we observe in the economy is the *simpliciter* relation, but what is relevant to maximise welfare is that accruing to the community: what can we say about the relation between what we observe and divergences between marginal social and private net products?

Firstly, Pigou notices that decreasing supply prices for the community are possible and frequent: in reality, it often occurs that, when an industry increases in size, the input requirement for unit of output of the equilibrium firm decreases. This happens because the bigger demand of the industry allows for a greater specialisation of firms: each of them can concentrate on one part of the production process and lower the quantity of resources needed to supply the final product.

Increasing supply prices from the standpoint of the community are instead less easy to

find in actual world. Pigou reckons they are rather improbable. His reasoning goes on this way: consider a firm purchasing factors of production only (the Professor here means by factors of production inputs not produced by other industries, i.e. whose price can change not because of altered efficiency but only because of changed conditions of demand: from the standpoint of the community then factors of production are always characterised by constant supply prices). If the output of the industry increases, the firm will be able to produce, using its inputs, at least the same output as before. The rational is the following: if some technological improvements take place because of the growth of the industry, e.g. because of specialisation, the firm will adopt them, otherwise it will continue to run the production process in the same way as before.
Extending the argument to the more general case of an industry purchasing also other ingredients, we see that technological improvements, due to increased demand, of firms supplying intermediate factors of production can lower the price of them. This change in price matters this time also from the standpoint of the community because it's due to the fact that a smaller quantity of inputs is needed to produce the same quantity of intermediate inputs. Since, as we have noted before, it is very unlikely that the growth of an industry purchasing only factors of production reduces its efficiency, then this must also hold true for other industries, because their inputs's industries must conform to the law of decreasing supply prices.

Let us pass to analysing the supply price curve from the standpoint of the industry: we want to know, if an industry conforms to increasing or decreasing supply prices from the standpoint of the industry, which is what we can easily observe, what can be said about the behaviour of supply prices from the standpoint of the community, which is what is needed to maximise welfare.
In general the growth of output of an industry, since it increases the demand for its inputs, leads to a rise of their price, so that, even though the same quantity of inputs is needed to obtain a given quantity of product, the monetary cost becomes higher.
According to Pigou, then, there can be only decreasing supply prices from the standpoint of the community, while the price of inputs can only increase because of an increase in output. Therefore, since the *simpliciter* supply price curve is a function of both changes in price and changes in physical requirement of inputs, the following conclusions are brought about.
If decreasing supply prices *simpliciter* rule it must be so because there are decreasing

supply prices from the standpoint of the community: it cannot happen that supply prices decrease because prices of inputs (not due to improvements of their production function) have decreased. Therefore, every time we are in front of an industry with decreasing supply prices *simpliciter,* marginal private net product must fall short of marginal social net product, because the marginal addition of resources lowers the input requirement of all the preceding units of resources.
If increasing supply prices *simpliciter* rule instead, we cannot say with certainty that marginal private net product is greater than marginal social net product because the data used are spurious of the effect on supply prices of input prices: we cannot conclude that increasing supply prices from the standpoint of the community rule – indeed, Pigou holds this is not possible. Therefore, if we are in front of an industry with increasing supply prices *simpliciter,* we cannot say whether or not economic welfare is maximised.

The Pigouvian natural answer to the discrepances between marginal social and private net products is in the form of granting bounties or imposing taxes. In the case of external effects on producers of the same commodity, then, what can be said, and Pigou actually states, about the eventuality of state intervention is as follows. In the presence of decreasing supply prices *simpliciter* there is the presumption that the concession of a bounty can improve economic welfare, and, if it were possible to precisely separate the effect on input prices that run in the opposite direction as the effect on input requirement, it would also be possible to find an optimal rate of bounty able to maximise welfare. On the other hand, in industries with increasing supply prices *simpliciter* nothing can be said about the point of view of the community, thus state intervention in the form of taxes is not justified here.

1.5.1.3.2 The discussion on empty boxes

It has been said, from the very start of the discussion on externality (see Clapham [1922]) to more recent writers (see Barnett and Yandle [2005]), that the discussion over increasing, decreasing or constant costs is not very useful since in practice it is very difficult to identify industries belonging to those different classes because of the extreme theoretic approach they imply. However, theory's task is just that of classifying empirical evidence according to similarities and differences that may not be evident in practice,

but are relevant for understanding the implications of economic actions. In this respect, the “empty boxes” contention is similar to the discussion on how to assess whether an assumption is realistic: Friedman [1953] convincingly argues that an assumption is not valid because it is a loyal representation of reality, but because the test upon its implications has been positive. Therefore, this alleged empty boxes are instead useful for the implications they contribute to explain.
I shall use Pigou's words to fill up the distance between theory and practice.

> *By means of it* [the classification in theoretical “boxes”] *we are enabled to see, for example, what conditions are implicitly assumed when it is stated that the imposition of a tax or the introduction of monopolistic policy will have such and such consequences. We are thus put in a position to detect and expose sophistical dogmatism. It is better to know exactly what facts are required to make the answering of a question possible, even though those facts are unattainable, than to rest in a fog of vague and credulous opinion. But this is not all. Difficult as it must necessarily be to classify industries into the categories which analysis has distinguished, we need not yet conclude that it is impossible. [...] Able business men with a detailed realistic knowledge of the conditions of their several industries should be able to provide economists with the raw material for rough probable judgments. Economists unaided cannot fill their empty boxes because they lack the necessary realistic knowledge; and business men unaided cannot fill them because they do not know where or what the boxes are. With collaboration, however, it is not unreasonable to hope that some measure of success may eventually be achieved. At least the effort is worth making. It is premature, in impatience at the present shortage of straw, to scrap our brickmaking machinery. It is the better part to advertise abroad the urgent need for straw, and to call for students to produce it.* [p. 168]

1.5.2 Monopolistic competition

It is now the moment of analysing divergences between private and social product under non purely competitive markets, namely monopolistic competition, faced in this section, and bilateral monopoly, described in the next one.

There is monopolistic competition when the supply side of the market is characterised by many seller firms the size of which is big enough to influence the market. In this case there is room for competitive advertisement to transfer demand from a firm to another, especially when the quality of the good is not completely homogeneous and not readily testable before – or immediately after – purchase.

It must be noticed that not all advertisement is competitive: in some cases, when there is no reference to a specific firm, advertisement is directed not to transfere demand, but to make consumers aware of the existence of the commodity. This practice does not produce external effects since it is in the interest of the community that the knowledge of new products is spread: private interest is here aligned with the social.

In the case of strictly competitive advertisement instead, the transference of demand from one firm to another, while having a considerably high private return, is unlikely to have the same effect on society. When the producers of a commodity, operating under monopolistic competition, make investments in striclty competitive advertisement there are three cases that may occur. Firstly, it may happen that eventually the result of spending resources to attract demand is that producers make an agreement between them: in this case they act as if they were a single monopolist and it is not possible to say whether the monopoly outcome so reached is better than the outcome that would have been produced under monopolistic competition. Thus, since the product of the expenditure in advertisement is in this case the presence of a monopoly, it is not possible to state whether the social net product of this expenditure is positive.

Secondly, it could happen that the advertisement costs sustained by producers neutralise one another. The marginal social net product in this case is negative because resources devoted to advertisement could be spent in some activity having normal return. Also the actual private outcome is negative, even though the choice had been necessarily taken with positive expected net product.

Thirdly, expenditures made by some firms can succeed in attracting demand towards

their supply. In this case the social outcome is positive if the substituted goods are produced by the least efficient firms. However, inefficient firms often try to compensate their competitive disadvantages by increasing advertisement, therefore the marginal social product of resources devoted to it is likely to be negative.
In conclusion, the marginal social net product of expenditures in advertisement is, according to Pigou, very unlikely to be as large as the incremental product accuing to the private. Therefore, unless there occurs to be some agreement between competing firms not to advertise, it is possible for the state to intervene through taxation or even prohibition of competitive advertisment if the conditions causing monopolistic competition could not be torn down.

1.5.3 Bilateral monopoly

There is a bilateral monopoly when there is only one buyer and one seller interested to the deal. In this case a market framework is not present and parties can spend resources to try to alter the ratio of exchange in favour of them. Within the range of values standing between the minimal price acceptable by the seller and the maximum price that the buyer is willing to pay, any price is equally good from the point of view of the society. The total surplus is always the same: what changes is the proportions of consumer and producer surpluses, so that the private product of efforts devoted to modify price have always a social net product falling short of the private.
These efforts can assume different forms: that of bargaining proper and that of deception. In the first case, even though the activity is not illegal because it does not imply any fraud, Pigou reckons absolute prohibition is needed because, if resources devoted to this activity have been taken away from other investments yielding normal return, then the social net product of bargaining is negative. Since no tax yielding revenue can level out divergences between a positive private net product and a negative social one, the only optimal solution would be that of forbidding bargaining. However, this solution is clearly unfeasible. I add that it would not increase total welfare since it would be a dramatic limitation of individual freedom.

As of deception, in blateral monopoly it can assume two forms: cheat on the quality or quantity of the good sold and on the yield that the investment object of the contract can give in the future. Both imply the communication of wrong information to the buyer with the effect of increasing the expected private return of the operation, were it money return or satisfaction. Thus, one party is led to undertake an investment in the view of obtaining something that he or she will not attain. If deception leads to increase production in the good that is object of false description, then the social net product is negative, since those resources could have been spent in something having normal return – that is, having a return given by the actual characteristics of the product. The source of the negativity of the social outcome is the fact that the consumer purchases something that is promised to yield him some satisfaction that will not actually take place. Then, comparing this with a situation in which the promised satisfaction does take place and using this last case as the opportunity cost of the operation, it follows that the social net product must fall below zero.

Therefore no tax with a revenue can prevent deception from being done and absolute prohibition is needed. Let me add that, while bargaining proper constitutes only a waste of resources from the point of view of the community, deception has also social consequences because of the unfairness of its result, i.e. an exchange not actually wanted by one party.

1.6 Conclusion

In conclusion, “The economics of welfare” constitutes a great contribution to economic studies for the number of issues raised and the depth with which the analysis has been performed. The author starts from the basic principles, coping with every specific concept to clear the ground and avoid misconceptions. Even though the wealth enhancing purpose prevails, other aspects of social life are always accounted for. One could disagree on or be skeptical about the possibility for the state to actually fix problems, however no one could say that Pigou's analysis is not, other than monumental,

also very useful. Indeed, at least, it raised the issue of the possibility of some “failure” of the market process, and it is thanks to him, who strongly highlighted the point, that we can now guess that the failure – and sometimes the solution – is to be found in institutions rather than in the market.

As a confirmation of Pigou's importance there is the massive flow of literature that followed “The Economics of Welfare”. It is the purpose of the next chapter to illustrate a few insights that can be drawn from it.

Chapter 2
Externalities

2.1 Introduction

In “The Economics of Welfare” Pigou takes the Marshallian idea of possible divergence between the return accruing to the individual who carries out an economic cause and the result it brings about on society as a whole, and examines it in detail, putting forward a number of examples referring to different market structures and different classes of victims and gainers. Because of the wide range of situations that the analysis faces, later economists have felt the need to classify the effects according to the economic variables they act upon. In the present chapter the focus is on the concept of externality, one particular case – perhaps the most relevant – of external effects. The literature on this concept is so wide that we had to make a selection: the concepts highlighted in next sections are those which seem more useful to understand the limits and the abilities of the market in capturing the essence of transactions.

We start by defining what externalities are, using the definition put forward by Baumol and Oates [1988]. It has been chosen because it identifies the economic phenomenon leading to violation of economic efficiency, while other proposed definitions explain externalities not for what they are but for what they do, which is surely useful, but at a later stage of the analysis.

> *An externality is present whenever some individual's (say A's)* utility *or* production *relationships include real (that is, nonmonetary) variables, whose values are chosen by others (persons, corporations, governments) without particular attention to the effects on A's welfare. The decision maker, whose activity affects others' utility levels or enters their production*

> *functions, does not receive (pay) in compensation for this activity an amount equal in value to the resulting benefits (or costs) to others.* [p. 17, emphasis in original]

Two points have to be noticed. First, affected variables have to be non monetary: this allows for changes in parameters of utility functions and for changes in quantities, but it does not admit changes in prices. Second, the effects must not have been looked for by the decision maker.

As of the first point, it recalls one of the most cited definitions in the literature (one of those which define consequences), that of Viner [1931], which separates pecuniary from technological externalities. Pecuniary are those affecting prices only, and they are not considered strict externalities because they are normal effects of market transactions: for example, when many people by some good in an amount sufficient to cause an excess of demand, then the price rises. Technological externalities are those relevant because they are not captured by the market process.

Another dinstinction of external effects is that proposed by Buchanan and Stubblebine [1962]. They distinguish among marginal and inframarginal externalities, Pareto-relevant and non Pareto relevant externalities. Marginal externalities are those affecting the marginal consumer, hence the conditions of optimality, while inframarginal are those which affect the total utility of the victims without modifying equilibrium conditions (that is, the marginal consumer is unaffected). Both these kinds of external effects are potentially relevant, but become relevant only when they satisfy the conditions of Pareto relevance.

> *An externality is defined to be Pareto-relevant when the extent of the activity may be modified in such a way that the externally affected party, A, can be made better off without the acting party, B, being made worse off. That is to say, " gains from trade " characterise the Pareto- relevant externality, trade that takes the form of some change in the activity of B as his part of the bargain.* [p. 374]

In other words, when the payment which would internalise the externality does not change the extent of B's activity, the externality is not Pareto-relevant.

A very large number of definitions has been proposed (see also Meade [1952] for what

regards external effects on firms), and we do not want here to tackle all of them. We only wanted, in this introductory section, to give an upshot of how the literature refined the concepts put forward by Pigou, to introduce the reader to the concepts of this chapter. In next sections we put on a side definitions and tackle two major critiques of the apprach of "The Economics of Welfare", put forward by Knight and Coase.

2.2 Knight: excludability

One of the first attacks to Pigou's result involving enhancement of welfare through state intervention has been put forward by Knight in an article dating 1924, the year when the second edition of "The Economics of Welfare" had been published. The edition which the treatment of the first part of this thesis refers to is the fourth, printed in 1932. This last edition does not contain, among the examples of divergence between private and social product, one case, reported in the second edition, that has extensively been treated in the literature: the case of the two roads.

Suppose there are two roads connecting two points: one is broad enough to allow for a virtually infinite number of trucks using it, but it is poorly paved; the other is narrow but better surfaced, so that trucks using the second road incurr lower costs in covering the same distance, so long as congestion does not step in: since the good road is narrow, after a certain number of trucks using it, the entry of new ones creates traffic, augmenting the cost for all other vehicles in the road.

Trucks will distribute themselves among the two roads in such a way as to equalise the marginal private costs of using them: trucks will enter the good road to reap the opportunity of lower cost; by doing so they increase such cost, and they do so until the difference is cancelled and the marginal cost of the alternatives levelled out. Hence, the advantage of having the good road is nullified. The resulting total product is not maximised because an inferior number of users of the narrow road would allow for greater returns to them – in terms of lower travelling time – without altering the returns to those transferred to the poor way. This is so because the industry "good road"

displays relatively upward-sloping cost curve: increasing the output, conceived of as number of trucks, by one unit, the per unit cost rises (hence, all other units suffer from the rise), so that the curve representing the marginal cost for the whole industry is steeper than that of the marginal cost referred to the additional truck, because it takes account of the negative effect the addition causes upon other units.

The Pigouvian solution to the problem, as appeared in the second edition, is as follows. Since total product is not maximised because the marginal private unit does not take into account the cost it imposes on other units, there is room for state intervention. The authority can impose a tax on vehicles using the good road that reflects the external negative effect due to congestion, so that each entering truck faces a marginal cost curve equal to that of the community. This way, fewer trucks will enter the better road, diminishing congestion. Knight in his article makes use of the following graphs.

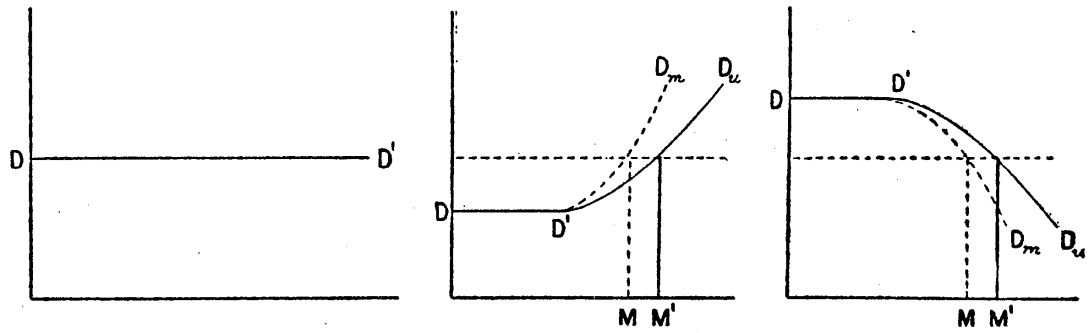


CHART A and B CHART C CHART D

Chart A and B represents the marginal cost curve of the poor road, horizontal, since more trucks do not affect the costs of other vehicles. Chart C represents the cost curve of the good road, with DD'D*u* being the marginal private cost and DD'D*m* the marginal social cost curve. Without government intervention, Pigou argues trucks would enter until M', being the optimal quantity M. A properly set tax, by making trucks consider DD'D*m,* can induce agents to behave in the optimal way, i.e. maximising social product.

Knightian argument against state intervention arises from the consideration that, if the road can be owned, than the owner will charge a price such that the socal product is maximised. In fact, what the entrepreneur looks at is chart D, showing the returns on successive units of investment. The cost of a unit of output is the value of the investment

needed to produce it in the aternative road, the horizontal line. Curve DD'D*u* reports the (gross) return on the added unit (average measure), and DD'D*m* reports the revenue it adds to the total, accounting for the fact that all previous units decrease their yield: the marginal product. Chart D is just the reverse of chart C, however setting the analysis this way it is easier to see that ownership could actually solve the problem. Indeed, if the road belonged to a private agent, he would set the price in the profit maximising way, so as to make marginal return (DD'D*m* in chart D) equal to marginal cost (the opportunity cost of the poor road), at point M in charts C and D. The economy would not be pushed over to M' because it would not be in the interest of the entrepreneur to do so. The price charged would be just equal to the Pigouvian tax and would serve the same purpose.
Knight states that the poor road cannot charge any price because

> *[...] if an agency of production is not subject to diminishing returns, and cannot be monopolized, there is, in fact, no incentive to its appropriation, and it will remain a free good. [...] The point is that any opportunity, whether or not it represents a previous investment of any sort, is a productive factor if there is sufficient demand for its use to carry into the stage of diminishing returns the application to it of transferable investment. The charge made by a private owner for the use of such an opportunity serves the socially useful purpose of limiting the application of the investment to the point where marginal product instead of product for unit is equal to the product in free (rentless) opportunities [...] and it thus maximizes utility on the whole.*
> [Knight 1924, p. 587, 591]

The key condition under which knightian argument is applicable is the presence of a characteristic of the so-called private goods: excludability. In modern public economics literature, a good is said to be private if it is excludable and rival (see Hindriks and Myles [2006]). The first adjective refers to the possibility of preventing people from using the good; the second means that the utilisation of a person impedes the use by others. Hence, an apple is both rival and excludable because I can exclude others from the consumption of it, and because once I eat it, it is not available any more to other consumers. Lights on the streets, on the contrary, are non excludable and non rival because once the light is installed, anyone passing around enjoys it and her consumption does not obstruct the use by others. In the case of the road, rivalry is present only when

congestion starts: once more and more people use the narrow road, previous users are affected. If the road is also excludable, for example by putting turnpikes, then Knightian solution is feasible.

The difference in approach between Pigou and Kight clearly reflects their different points of view about the state. As pointed out at the beginning of the previous chapter, Pigou regards competition as a force driving resources towards their best allocation, provided the rules of the game are properly set. These rules comprend state intervention in those industries showing some characteristics that bring about a divergence between the product accruing to the owner of the resources and that accruing to the community as a whole. Knight instead is more skeptical about the state, and regards competition as the force that can alone guarantee the best allocation, provided that agents are left free of seizing opportunities, that is, provided they can appropriate factors of production and their returns (excludability).

The discussion on excludability has gone further. After Marshall, and later more extensively Pigou, pointed out that there is often divergence between private and social returns, the issue of the indirect consequences that economic actions have has gained relevance. These are called external effects when they are not reflected in the price, or more generally, when they are not accounted for in bargaining. When this happens, resources will not be distributed optimally, according to welfare economists.

However, some authors have noticed that virtually every economic action has some consequence that had not been accounted for when undertaken. Even the most common and indiscussed example of private good, socks, yields external effects: wearing socks prevents deseases; not wearing them may result in decreased production because of spread illness, "*it means possible contagion [...]; it may result in rising doctor bills and increased health insurance premiums for other policyholders. Increased demand for doctors' time and energy will result in reduced medical attention for others,*" (Block [1983], p. 2) and so on. In fact, among the examples of divergence between marginal social and private product that Pigou offers in his "The Economics of Welfare", there are some which fall within the very nature of economic actions. When he talks about foreign investment, for example, he says that "*if foreigners can obtain some of the exports they need from us by selling promises, they will not have to send so many goods; which implies that the ratio of interchange between our exports and our imports will become slightly less favourable to us.*" (Pigou [1932], p. 140) Hence, social product is lower than the private, and according to him there is room for intervention. However,

seeing things this way, it is very easy to find reasons for state intervention in almost every human activity. It is for these reason that an entire literature about the definitions of externalities arose, some examples of which have been presented in the introductory section of this chapter: to separate cases in which external effects are relevant from those not constituting a problem for the normal functioning of markets.
Going back to the case of the roads let me conclude the discussion on excludability with a statement by Block: "*Highway sign-posting is a public good only when private ownership is forbidden and no price is charged. It becomes a private good just as soon as the externalities are internalised by the market.*" (p. 6)

2.2.1 Increasing, decreasing and constant returns

It is not difficult to see why Pigou removed this example from later editions of his book: according to him, no industries can have increasing supply prices from the standpoint of the community. From community's point of view only changes in quantities of inputs needed to produce a certain amount of output matter: in this case, input is time and output is trucks going from one point to the other. Hence, increasing the output of the industry, the input needed for each unit increases, and this contradicts the impossibility of having increasing supply prices. The point is that usually output is conceived of as a flow over a period of time, while this setting of the analysis reverses the issue, putting time among the inputs. The concept of increasing supply prices, described in the previous chapter, refers to the normal concept of output as a quantity over a period of time, and it refers to normal inputs different from time thus it cannot apply here: if additional trucks entering the road increase the time spent by each other truck in the industry, then the output conceived of as number of trucks covering the way *in one hour* may well remain constant, just because of congestion, even though more trucks entered. The point can be seen in this way: vehicles entering the highway are the inputs, while the output is the number of loads brougt to destination in one hour. The argument on congestion says that when an additional unit of input is invested, then total output may not increase because it takes more time for every vehicle to arrive. Hence,

congestion does not mean increasing supply prices from the standpoint of the community.

It is now useful to see how differently Pigou and Knight approached the issue of the laws of increasing, decreasing and constant returns, or decreasing, increasing and constant costs, or supply prices, as Pigou prefers to say.

Knight states: "*valuation is an aspect of conscious choice. [...] The natural and common rule in choice is necessarily that of increasing cost*" (p. 594). First of all, this is so because of the decreasing nature of marginal utility: giving up more and more of A against B, the subjective value of what is left increases and that of what is taken in decreases: that is to say, the opportunity cost of B (the value of A given up) increases, while the return (utility) it yields decreases. Hence, as the output of an industry increases, its cost, in terms of what is given up to produce it, rises, while its product, in terms of utility, falls. Secondly, and more importantly, apart from the law of diminishing utility, when an industry increases its product, it usually takes the resources needed to do so out of some other industry, the output of which is being diminished. When this happens, Knight says, the productivity of the shifted resources worsen, because they are more suited for the production of the good which they were previously devoted to. Hence, the real cost of producing any good rises as output increases (real values are what is relevant, according to Pigou, from the standpoint of the community). To these considerations, Knight adds that also the market price of the shifted factors will rise, and with it also the price of other resources already in the industry.

As of decreasing costs, according to Knight they can occur in first instance because of the economies of scale that can be obtained by enlarging the production of the commodity. However these economies are obtained as a consequence of the greater size of the firm, and they are indipendent of the output of the industry. Hence, economies of scale do not make an industry be of decreasing costs. In competition, and in the presence of economies of scale, the industry ends up either in monopoly, or in "*leaving the tendency behind and estabilishing the normal relation of increasing cost with increasing size*" (p. 597), i.e. in exausting all opportunities deriving from the available economies.

Other alleged sources of decreasing costs are stimulation of demand and stimulation of inventions. According to Knight, these are not effects of increased output. Raher, they are causes of it. New inventions make it possible to produce more and more cheaply, it is not a bigger output that stimulates inventions. Hence, inventions belong to the "ceteris paribus" condition, they cannot cause the decreasing cost nature of an industry.

Knight thus rules out the possibility of having decreasing cost industries, unless they are monopolies (in this case the size of the industry and that of the firm are the same thing hence economies of scale become relevant to the industry).
Thus, in his article "Some fallacies in the interpretation of social cost" Knight concludes in the opposite direction as that of Pigou. Interestingly, he does not directly face the Smithian concept of specialisation of labour, the main source of diminishing costs to the industry according to Pigou. He does consider the issue indirectly, when he talks about increasing costs: according to him, the shift of resources from one industry to another must necessarily reduce their productivity, for the reasons explained above: no specialisation occurs because of increased output; instead, resources already specialised for the production of a good, in the transfer to the production of another good, the output of which is being augmented, lose some of their productivity. When the output of an industry rises then, its cost rises as well.

The Pigouvian concept of increasing, decreasing and constant supply prices, already mentioned in last chapter, rests on the concept of the representative firm. In the article in which Knight discusses his conception of increasing, decreasing and constant returns, he does not even touch on this concept. The representative firm is a sort of "average firm", that need not exist in reality, but is used in theory because it sums up the characteristics of the industry and of the firms operating in it. Using the words of Marshall, the "inventor" of this concept:

> [the representative firm is] *the particular sort of average firm, at which we need to look in order to see how far the economies,* internal and external*, of production on a large scale have extended generally in the industry and country in question.* (Marshall [1890], p. 318, enphasis in original)

When the output of the industry increases, the cost curves of the representative firm also change. Because of specialisation, Pigou says, this change will generally be a downward shift. The new equilibrium, since it is always at the point in which average and marginal cost curves cross, that is the lowest point of the average curve, will then generally correspond to a lower per unit cost. There is no rule that estabilishes the reaction of the output produced by the single representative firm. One conclusion that follows from that

is that economies of scale matter only when the industry is a monopoly, like in Knight. However, the two authors conclude in extremely different ways, since according to Pigou there can be no increasing cost industries. He argues that when the output of the industry increases, then the firms operating in it must at least be able to produce the same things as they did before, at the same (real) cost. Therefore, cost cannot increase with industry's output.

This is how I see the issue. Increases in output can take place for two basic reasons. Either people's preferences have changed in such a way as to demand a greater quantity for every price, or firms' costs have changed and now permit to obtain the same output as before, at a lower cost. The second case is not considered to be a source of decreasing cost, because we talk about decreasing costs when the fall in cost is brought about by the increase in output, not vice versa (technological changes not due to increases in output are ruled out: ceteris paribus).

It may well happen that people's preferences shift in favour of the good, demand is increased, and the greater output allows for specialisation and decreasing costs: external economies shift the cost curves of the equilibrium firm both down and to the right: higher quantity, lower cost. This situation is depicted in chart E.

But it may as well happen, for the reasons explained by Knight, that the equilibrium cost is higher: the marginal and average cost curves shift upwards and to the right. This situation is depicted in chart F.

Chart E: increase in demand with specialisation

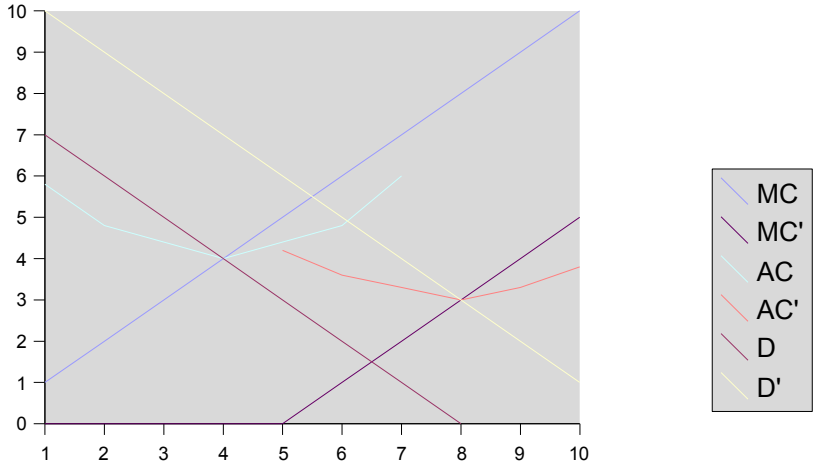
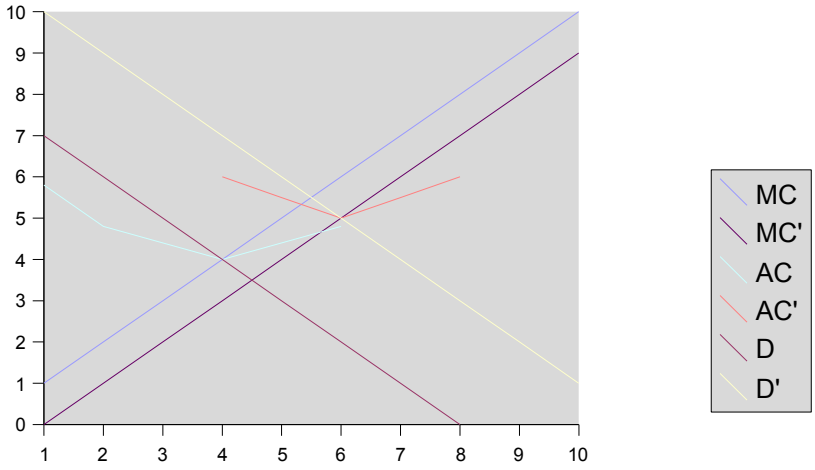


Chart E: increase in demand with no specialisation



How to reconcile these two possibilities? I believe the key point is the extent of the demand rise. Great demand shifts, leading to high potential increases in output, can allow for specialisation and decreasing costs. When the expansion of demand is not big enough, then the arguments put forward by Knight can take place. The needed magnitude of output change needed to spark external economies of specialisation depends upon the characteristics of the market, such as the initial number of firms, the potential of specialisation of the production process, but also the "biological" characteristics of entrepreneurs (see Prendergast [1992]).

2.3 Coase : reciprocity and transaction costs

2.3.1 Reciprocity and efficiency

Perhaps the most important and well-known critique to Pigou's work and conclusions has been put forward by Coase in his article "The problem of social cost", published in 1960.

Coase is part of a stream of the literature called “Law and Economics” (comprehending also Posner, Epstein and many other authors) for the stress placed on the role of the judge and the importance of definition, assignment and enforcement of property rights in economics.

The article aims at disproving the need for state intervention, and also points out that Pigou's solution may get things worse. The first reason for this follows the principle of reciprocity: so far we have considered causes the adoption of which by A inflicts harm on B. However, the problem can be seen the other way around: preventing A from carrying out the action entails a harm for A. “*To avoid the harm to B would inflict harm on A. [...] The problem is to avoid the more serious harm.*” [p. 1] Coase takes as an example the case of two adjacent lands, one devoted to cattle raising and the other used to cultivate crops. If cattle strays onto crops, some of the crop will be destroyed. According to Pigou, the cattle-raiser should either be held liable for the damages caused, or be prevented from raising cattle there, or be compelled to build a fence.

Coase's view is dramatically different. According to him it does not matter the acquired right of the farmer on his land. The main point for him is the fact that by preventing cattle from straying the breeder would reduce his production while by letting cows trespass, crop production would be decreased. The two alternatives should be compared to decide who should be allowed to harm whom, the market price of the supplies lost being the means of comparison, and efficiency the criterion. In some cases the best allocation is reached by the parties through bargaining; in other cases the judge steps in and decides himself property rights distribution, according to the efficiency criterion. Apart from the complete departure from subjectivism that the consideration of market prices only entails, this approach is rather puzzling: should a thief be allowed to steal if he can make from the booty an output that the market values more? It is true that also Pigou's goal is that of maximising social efficiency, but in his view there must be a presumption that the non economic part of welfare does not run in the opposite direction. That is, total welfare is enhanced by maximising economic welfare only if there is not evidence that other considerations lower non economic well being. In my view letting the cattle-raiser invade neighbor's property is a non justifiable – even less justifiable with efficiency – encroachment upon the farmer's rights, and this definitely represents a diminution of non economic welfare. One could argue that taxation is an encroachment of property rights either, and I think it is, but at least in this case it is the community who takes the direct benefits, not in terms of enhanced efficiency but in

terms of a greater budget to be spent for the common interest: I am not saying it is just, but at least it creates less injustice then making an owner pay a neighbor for the use of his own land.

2.3.2 Transaction costs and the Coase theorem

Let us analyse Coase's point more closely. First, the concept of transaction costs has to be defined.

> *In order to carry out a market transaction it is necessary to discover who it is that one wishes to deal with, to inform people that one wishes to deal and on what terms, to conduct negotiations leading up to a bargain, to draw up the contract, to undertake the inspection needed to make sure that the terms of the contract are being observed, and so on. These operations are often extremely costly, sufficiently costly at any rate to prevent many transactions that would be carried out in a world in which the pricing system worked without cost.* [p. 7]

When the pricing system works smoothly, that is, when transaction costs are zero, then the best allocation of resources – the most efficient – will be attained, according to Coase, irrespective of the initial distribution of property rights. In fact, there are two possibilities. If the breeder is liable for the damages caused by his steers, than he will let his cattle stray only if the value of production deriving from it is greater than the damage suffered by the farmer. In this case the right is on the farmer's head and the best allocation is always reached because if the market value of production of the straying cattle is lower than the destroyed crops then the breeder will not allow his steers to overstep boundaries while in the opposite situation he will allow them and pay for the damages: the resources will in any case be allocated in their best use.
If instead the breeder is not held liable of the damages caused, then the farmer can bargain with the breeder not to make the cattle stray. He will do so only if the market value of the lost crop is greater than what the breeder asks, which in turn is equal to the

market value of the production he obtains from letting cows go beyond the limits of his property. In this case the property right would be on the breeder's head (otherwise the farmer would not have to pay for using his property), but resources would still be allocated in the most efficient way.

Hence, according to Coase, in an ideal world where there are no transaction costs the most efficient allocation of resources comes about irrespective of the distribution of property rights. The role of the judge is only that of redistributing rights according to some fairness criterion, with no efficiency considerations.

It is the so called Coase theorem: in the presence of externalities, with no transaction costs, trade will lead to an efficient allocation of resources, regardless of the initial distribution of property rights. This statement looks for some respects similar to the first fundamental theorem of welfare economics, even though, differently from the fundamental theorem, it does not make use of utility functions: let the market work and an efficient allocation will always be attained. The difference is the stress placed on transaction costs: when these are present, bargaining may not occur and externalities may not be internalised.

Unfortunately, the world is full of transaction costs, firstly (but not only) because of the not complete information agents can rely on. Therefore, the presence or absence of liability rules, that is, the allocation of property rights, makes things different, in that ownership will not – at least, not without some waste of resources – go to the most worthy opportunity.

In the example used above, if the cost of bargaining exceeds the gain in efficiency that the transaction would bring about (i.e. they are greater than the differential of the market value of production in the two activities), than the deal does not take place and resources may be misallocated. It is then the role of the judge to make a case by case cost-benefit analysis to discover the most productive owner and thus assign him property rights so as to enhance efficiency and wealth. In the example above, the judge should impose liability when the damage on farmer's production has a greater market value than the breeder's increase in production due to cattle-straying on his neighbor's property, and vice versa.

Here we can better understand the reciprocity argument: we usually see the property rights allocation as given hence we are led to see only one way of the relationship. But if we can decide how to assign them then we will see that giving them to one inflicts a harm on the other, and vice versa. The criterion according to which the assignment

should be done is efficiency.

As an evidence of the blindness of Pigouvians, Coase cites the fact that Pigou indicates as a case of private product falling short of social product the installment of smoke-preventing devices by firms, suggesting a bounty aimed at correcting the divergence, while in the Pigouvian literature pollution tax is the means mostly used to correct the higher private product resulting from not considering environmental costs. If economists had noticed that the problem can be seen in two opposite ways they perhaps would not have been misled to their conclusions.

I reckon reciprocity is an important insight put forward by Coase, however, if the criterion according to which assignment is done is efficiency, then there is no certainty about property because we could always see our things given to others who use them "better". Therefore, even in an efficiency seeking setting, losses deriving from the presence of uncertainty would probably offset the gains obtained. If we also consider the fact that people are provided with *cognitions, emotions and desires (*Pigou [1932]), than the psychological pain deriving from deprivation of what is ours may play a role, and make non economic welfare change in an opposite direction than economic growth.

On the other hand, if the efficiency criterion is only something that has to be taken into account, being another criterion – hopefully moral this time– the most important, then we could say that efficiency in property rights assignment falls down to the concept of good sense, or avoiding waste.

According to Coase, the judge should intervene whenever transaction costs are present, even though they do not prevent bargaining. The only presence of such costs represents a waste because they are not productive: were property rights already attributed to the most efficient owner, there would be no loss of resources. The problem with this position is that transaction costs are always present, therefore the judge would always be legitimised to question the original ownership. A positive insight is instead the provision that transaction costs should be kept as low as possible.

2.3.3 An interesting position

An interesting position in this discussion is that sustained by Colombatto [2011]:

> *[...] economic action entails two categories of expenses: exchange and institutional costs. The former refer to what it takes to satisfy our needs, once we decide to explore the possibility of exchanging. The latter consist of monitoring and enforcement: they are the costs of defending our liberty.* [p. 115]

Hence, institutional costs are those which are needed to protect property, not only for exchange, but for possession in general. If we live in a quiet place where we can even leave the key in our car, these costs are almost null; if we leave in a quarter where it is better to have a garage because there are often car thefts, then the institutional costs of having a car are far higher. It is true that they affect the opportunity cost in exchange, however they do not derive from bargaining. Exchange costs instead are those incurred when an individual looks for trade opportunities: looking for a counterpart, searching for information on the object of the contract, and so on. State intervention should only minimise institutional costs, because they are waste due to lack of enforcement of rights. Exchange costs do not represent institutional failures but are instead normal costs. For example, when we have to decide whether to buy something in our city or to go to Milan where there are more shops, we definitely include in the second opportunity the traveling cost. It is true that it may be so high as to make us decide for the other possibility, however they just represent a normal opportunity cost. According to Colombatto [2011], they are more likely – and I think it is more desirable to defend our liberty – to be reduced by voluntary cooperation rather than Government intervention.

2.3.4 A not very illuminating critique to Pigou

Coase has no doubt helped looking at the problem in a non conventional way, however reading his article it seems at times that he has not deeply understood Pigou's argument. He says: "*when an economist is comparing alternative social arrangements, the proper procedure is to compare the total social product yielded by these different arrangements. The comparison of private and social products* [does not matter]" [p. 17]. However, Pigou does compare alternative social arrangements. He starts from the consideration that, according to the "optimistic followers of the classical economists", private product is maximised through the market, which makes the marginal private products of virtually all activities align. The comparison of marginal products serves the purpose of finding the best allocation among the alternatives, and we know that the best one is that in which marginal products are equal, because otherwise the market would reallocate resources from that having lower marginal return to that having it greater. However, according to Pigou, the market not always works smoothly. There are cases in which there is divergence between the return accruing to the private agent and that accruing to the community. Since what we want to maximise is social product, then what should be equalised among different uses is marginal social product. Therefore, since the market pushes marginal private products close together, all we have to do is to render marginal private and social products equal.

Notice that the purpose of the comparison is to maximise social product: among all possibilities, we choose the best social arrangement, and this can be done through the comparison of marginal social and private products. One can surely disagree with the provision of aligning marginal social and private net products, however he could hardly say that there is not any divergence between social and private products, and even less could he say that Pigou's approach was wrong because he did not compare the total social products yielded by different arrangements.

2.3.5 The departure from subjectivism

The most important shortcoming of Coase's analysis is the complete absence of subjectivism. Apart from the already mentioned downplaying of *cognitions, emotions and desires*, that, if considered, would run against an economic-efficiency-based role of the judge, Coase does not discern market value from subjective valuations. His conception of willingness to pay is entirely based on the market value of the object of exchange. The fact that the farmer may want to cultivate his property for reasons other than production's market value, for example because all of his ancestors did so and he wants to continue the family's activity, is not even taken into account. However, this is a very important as well as old achievement of economics: value is subjective. Where does the market value actually take place? In the market, through the comparison of firms' costs with consumers' subjective valuation of output. By neglecting this, as Colombatto [2011] rightly emphasises, the consumer surplus loses its meaning, which is "*somewhat paradoxical, since the very notion of efficiency is not about maximizing production, but rather about maximizing the surplus enjoyed by the individuals*" [p. 118]

Moreover, even apart from the subjectivism argument, I cannot see how the acquired right of A on his things, for which he or his family has probably paid, can be reciprocal to the willingness of B to get possession of them with no payment (in fact, if the cattle raiser can make cows stray on the farmer's property with no liability, then he is the owner of the land without having paid for it). However, in other respects the reciprocity argument is useful, as for instance the mentioned possibility of granting bounties to firms installing smoking-preventing devices or taxing emissions.

2.3.6 Conclusion: Coase versus Pigou

In conclusion, both Pigou and Coase are rather consequentialist: both legitimise Government action to the purpose of efficiency, be it through taxes of through property

rights reassignment. However, while Pigou does consider the possibility that total welfare may be decreased by a cause enhancing economic welfare (because things like how income is earned and how income is spent can run in an opposite direction), Coase talks as if economic welfare were the final goal of economics. Pigou instead makes a presumption: if there is no evidence that a cause enhancing economic welfare worsens the part of welfare that cannot be measured with money, then we can proceed as if total welfare effectively increases. However it seems to me that often economists take this presumption as a postulate: something that is always true instead of something that could be discovered to be false but is considered true until contrary evidence. Edgeworth's "unverified probability" has – mistakenly – become an indisputable truth, and the growth of national dividend is now seen as an undoubted improvement of welfare. As recent experience shows, meliorating the proxies used to check the effectiveness of policies is often considered the goal, and efforts are devoted to improving the (short-run) values of these indexes instead of acting on the real sources of problems.

Coase's and Pigou's recipes for efficiency distinguish themselves because of the opposite ideologies from which they depart. The latter is evidently socialist in nature hence opts for taxes and bounties; the former is a free-market sustainer thus stresses the power of bargaining and property rights. The problem with Coase's argument for free market is that paradoxically his conclusion is not that Government should abstain from intervention. Rather, the conclusion is that the state has to intervene since it is responsible for the achievement of efficiency: it must reassign property rights the right way (instead of just enforcing the existing ones, as a real free-market sustainer would say) and it also must lower transaction costs. The task should not be left to the political arena because this would not guarantee independence of action. The judge is the most appropriate institution for this role, however it is still a branch of the state and everything the judge does other than enforcing rights implies state intervention.

To conclude, a final remark. When Coase criticises Pigou he suggests that we should consider total effect of social arrangements: Government intervention can improve the situation in that market but worsen other markets. This is surely true: it is the well known concept of unpredictable consequences of state action. However, it is curious that Coase, after having accused Pigouvians of being blind, himself does not see that, other than economic collateral effects, also non economic worsened conditions could play a role.

2.4 From pure theory to a simulation model

So far we have been concerned with theoretical methodologies, ideological discussions and in a minimal degree also with some history of economic thought. In the first chapter a description of Pigou's approach has been put forward, starting from the definition of welfare, national dividend, and other building blocks of welfare economics, going through the marginal analysis, and finally getting to the concept of divergence between marginal social and private net product. The second chapter has focused on externalities, the most frequently talked-about case of divergence: that in which, according to the Pigouvian literature, state intervention is definitely needed.

There are other cases of divergence, as emerged from “The Economics of Welfare”, and in the next chapter we want to use computer technology to simulate a scenario in which one of them appears. In particular the model deals with a situation in which there is a temporary modification of some parameters of consumers' utility functions, which is made on purpose (while strict externalities are unpurposeful), even though the driving goals may not be reached because of the difficulty of individuals' reactions foresight.

Chapter 3
A simulation model using NetLogo

3.1 Introduction

The model aims at simulating a case of purposeful external effects. Differently from the case of externalities arising when some agent does not account for the costs or benefits that their actions impose on others in terms of goods (without modifying their production or utility functions, but only affecting the quantities available) we here want to tackle a hypothesis in which utility functions of the agents are affected. In the first chapter we already came across a case of external effect acting through utility functions, however it was generated inintentionally. I am talking about the case of hats and diamonds, in which the satisfaction people derive from a given quantity of a good changes as a consequence of the consumption of other people. The wide spread of hats increases the utility attached to it by consumers, because it makes them in fashion. On the contrary, the rarer diamonds are, the greater the satisfaction deriving from owning one.

The simulation model we constructed refers instead to actions specifically headed to the purpose of altering consumers' utility functions (they represent divergence between social and private product but cannot be called externalities according to the definition provided at the beginning of last chapter): marketing promotion, lobbying campaigns, modification of the law. Indeed, we think that law-level norms have a direct effect on people's utility, which is limited in time because social norms eventually prevail. Moreover, we think that more often than not the result of actions aiming at changing utility functions is different from what they were designed to do. As you may have noticed, the analysis brought about through the simulation model is inspired by the part of “The Economics of Welfare” in which Pigou deals with divergences between social

and private products in monopolistic competition due to competitive advertisement. In that framework, Pigou did not mention the fact that some parameters of utility functions may have changed, but merely referred to transfers of demands from one firm to another. Clearly, these transfers can come about only through modifications of consumer's preferences, and are thus summarisable through utility functions alterations.
We tried to build a model able to represent reality in less simplified terms than how it is usually depicted: we insert production externalities (the model is a modified version of one proposed by Baumol [1988] to demonstrate the optimality of Pigouvian taxes), we add external effects on consumer's utility functions. Moreover, we introduced a hindrance to utility maximisation: for what regards one of the goods produced in the economy, it is possible, through the model, to make agents not decide the amount to consume according to the maximisation of their utility, but according to other criteria, for instance ideologies.
Differently from the purpose of Baumol's original model, we do not want to demonstrate the validity of any hypothesis. We want to see the working of the economy under these circumstances and assess what we can conclude in terms of equilibrium.

3.2 The rational of the model

3.2.1 Setup

The model starts assigning a utility function to each agent: all agents have the same form of utility function, but each one has a different value for the parameters. In particular, the utility functions take the form:

U = (x1 ^ a * x2 ^ b * x3 ^ c * x4 ^ (k * d) * x5 ^ f).

x1, x2, x3 and x4 are the quantities of the goods consumed by each agent; x5 represents their leisure, i.e. time not devoted to working; p1, p2, p3, p4 and p5 the respective prices

(p5 is the opportunity cost of leisure: the wage rate). x1tot, x2tot, x3tot, x4tot and x5tot are the respective totals: with no inventories, the first four correspond to the outputs of the four industries, while the last is total leisure. R is the total time endowment, the sum of all individual time endowments each equal to 80, comprehensive of hours of work and leisure. A possible interpretation is that the measuring unit is hours a week, so that there are 16 hours a day available to the worker for 5 days a week, to be distributed between work and leisure. The other 8 hours can be thought of as hours necessarily devoted to minimal vital functions. It is possible to change this setting just by modifying the value of R.

Each industry (let us define them here as X1, X2, X3 and X4, and the respective goods 1, 2, 3 and 4) has a specific cost function. X1 has a constant per unit cost of 0,75 and its operations impose a negative externality on X2, which has a production function of the form:

$$c2 = 0{,}75 * x2tot + (1 / 4) * 0{,}75 * x1tot.$$

X3 and X4 have greater costs of production (c3 and c4) equal to (1,25 * x3tot) and (1,25 * x4tot). The only input used is hours of labour, so the model is closed by the consideration that the total time endowment must be equal to the sum of c1, c2, c3, c4 (labour requirements) and total leisure:

$$x5tot = R - c1 - c2 - c3 – c4.$$

a, b, c, (k * d) and f are parameters, specific to each agent, that determine the utility they derive from each kind of good, respectively x1, x2, x3, x4 and x5 (leisure is a good). All of them must be less than 1, because of the postulate of decreasing marginal utility: increasing the consumption of a good, the agent becomes more and more satiated with it, and additional units give him progressively less satisfaction.

While a, b, c, d, and f are randomly assigned and fixed, k is a parameter that represents the possibility of altering the intensity of satisfaction people derive from good x4. It is not argued here that the other parameters are immutable. On the contrary they follow a trend over time, given by changes in preferences due, for example, to cultural evolution. This trend for simplicity is assumed to be constant (growth rate equal to zero) because we want to analyse the effects of divergences from it, not its direct consequences: hence, there is no loss of generality.

Since (k * d) must be strictly greater than zero and strictly less than one to assure increasing utility with decreasing marginal utility, and since d is a parameter specific to the agents that by hypothesis cannot be changed, then the values that k can assume are

those in the range (0; 1/d), not including the extreems. When k approaches 0, then the whole esponent approaches 0 as well: the utility deriving from consumption of 4 is relatively small. When k approaches 1/d instead, the esponent approaches 1 and not only the total utility affordable through consumption of the good increases, but the agent also gets less satiated with greater quantities (marginal utility decreases at a lower rate). In the first part of our analisys, we simply want to see what happens when there is no interference with agents' utility functions. Therefore, we set k equal to one: the exponent of x4 is d. We consider it equal to one even in the explanation of the procedures that is going to follow, to avoid confusion.

Agents are randomly assigned an initial endowment of each produced good, the minimum being 5 units for each good, the maximum 20. The reasons for this range will become clear later, sufficing here to say that, since agents are also workers in this model, then, a minimum of 0 for each good would be more unrealistic than the assumed range.

After having distributed 1, 2, 3 and 4 among agents, we sum them up to find the totals, x1tot, x2tot, x3tot and x4tot, which are needed to find the labour requirements to produce them: c1, c2, c3 and c4. We now can find x5tot as the difference between total time endowment (R) and the sum of labour requirements. Total leisure is then distributed among individuals in equal parts, so that each agent has the same leisure time. It could be argued that this is too a significant simplification, because it does not take into account the theory of the labour market, according to which workers can decide the number of hours to work on the basis of the wage rate, the intertemporal budget constraint, and other considerations. In actual world, however, workdays are not decided by employees. Legislation and production are the major determinants of the hours that workers are supposed to spend in their workplaces. For this reason, it does not seem to us unlikely that x5 is equal for everybody: total consumption determines production, which in turn limits the hours of leisure available to each worker.

Finally, prices are chosen randomly, in the range [0.01; 10), except for p5, which has a minimum of 1, interpretable as minimum wage.

All this initial settings are estabilished when the button “setup” is pressed: the number of agents is decided using the slider in the interface tab called “numberturtles”; prices are set; quantities and parameters of the utility functions assigned. Moreover, agents are located in the “world” on the basis of their values of x4 and utility: the x axis represents the former and the y axis the latter.

3.2.2 Go

Let us now describe the procedures regarding the process towards equilibrium.
The button “go” has two precedures: “find-equilibrium” and “move-turtles”. The first one makes agents optimise the quantities of the goods consumed, according to their marginal rates of substitution. Since in NetLogo there is not an automatic way to get the derivative of a function, we manually have to write down the marginal rates of substitution for each pair of goods, and we call them sms12, sms13, sms14, sms15, sms23, sms24, sms25, sms34, sms35 and sms45. Hence, we ask each agent to confront each of her sms's with the relevant price ratio. Let us consider as an example the pair of good 1 and good 2. The procedure goes as follows:

```
if (p1 / p2 - sms12) > (sms12 / 10) and x1 > 1 [
set x1 (x1 - 1)
set x2 (x2 + 1)
set p1 (p1 - 0.1)
set p2 (p2 + 0.1)
]
if (p1 / p2 - sms12) < (- sms12 / 10) and x2 > 1 [
set x1 (x1 + 1)
set x2 (x2 - 1)
set p1 (p1 + 0.1)
set p2 (p2 - 0.1)
]
```

If the marginal rate of substitution between 1 and 2 exceeds the price ratio by more than a tenth of such rate, and if the possessed quantity of 1 is striclty greater than one, then the agents gives up a unit of 1 in exchange for a unit of 2. The price of 1 then decreases, while that of good 2 increases. If, on the contrary, the marginal rate of substitution is less than the price ratio (with the same approximation) and x2 is strictly greater than 1, then good 2 is given up against good 1, p1 increases and p2 decreases. The rational is that of the Edgeworth box (see Katz and Rosen [1997]), with the difference that here there is not an exchange between two consumers: instead, each agent can give up a unit of a

good for a unit of another, with two consequences. First, prices change accordingly (as in Edgeworth box); second, the labour requirement needed to produce the new consumption mix changes, and consequently x5 changes as well. This second effect makes it possible to conceive the Edgeworth box in a single-agent setting, without a fixed total quantity of the goods to be allocated among consumers, the capacity of the economy being resumed by production function and time endowment.

To repeat, the conditions of agents' action are: excess or defeat of the marginal rate of substitution over the price ratio by a minimum difference, and having more than one unit of the good to give up. If none of them is satisfied, then the agent does nothing. The approximation is inserted because perfect equality between every marginal subjective valuation and the price ratio is not always feasible, both because of the number of agents continuing modifying prices and x5 to all others, and because, even with few individuals, the fact that prices can change by 0.1 and goods by 1 unit makes it difficult to reach the absolute equality. However, this setting is in my view more realistic than the usual perfect maximisation, because in reality equality between marginal subjective rates and price ratios almost never occur. I believe in fact that when people are in front of choices that involve the consideration of utility, they act as if they considered some utility function: they weigh what each action *adds* to their present utility, with respect to the cost born. That is, they confront marginal utilities with prices. The theorist will then say that the easiest way to summarise all the relevant information is to create marginal rates of substitution and price ratios, but the actual person hardly does so, and proceeds instead with a trial-and-error process, tending to that result, but hardly achieving it perfectly. Hence, the approximation is not unrealistic.

All four commands in brackets push sms and price ratio closer, therefore the conditions tend to become false when the procedure is run many times by the agent. However, the trend is disturbed by the other turtles running and changing prices.

Agents perform the procedure just explained for all couples of produced goods, but when leisure is involved another set of conditions and commands is in use. For example, when x5's marginal utility is confronted with that of good 1, this code applies:

```
if (p1 / p5 - sms15) > (sms15 / 10) and x1 > 1 [
set x1 (x1 - 1)
set p1 (p1 - 0.1)
set p5 (p5 + 0.1)
```

```
]
if (p1 / p5 - sms15) < (- sms15 / 10)  and p5 > 1 [
set x1 (x1 + 1)
set p1 (p1 + 0.1)
set p5 (p5 - 0.1)
]
```

If the marginal rate of substitution between good 1 and leisure is greater than the price ratio and the owned quantity of good one is greater than 1, then the agent gives up a unit of this good, without exchanging it for anything. The reason is that when the first condition is true, the utility deriving from the last unit of the good is less than what could be afforded by having one more hour of leisure. Hence, since x5 is uniquely estabilished by the production functions and good 1 has to be produced using hours of labour, then the agent reduces the quantity of 1 thinking to have in exchange some more leisure. The amount of leisure she will obtain, however, depends on the number of agents in the economy because the greater total leisure will be distributed among all workers.

The second "if" block differs also in another respect, the second condition. Since x5 cannot be changed directly by the agent, it would make no sense putting x5 > 1: in the case of pairs of goods not involving leisure, it was put just in order to make the exchange possible. Here, we impose p5 > 1. Reminding that the price of leisure is the wage rate, this condition states that salaries cannot fall under a certain value: the minimum wage. If both conditions are satisfied, the marginal utility of x1 is greater than the marginal utility of leisure: by increasing x1 total utility increases, and the agent just does so. As in the opposite case, the greater labour requirement needed to produce the additional unit of good 1 is shared with all other workers, and this creates an even greater incentive to increase x1: benefits are appropriated while costs are shared (I don't know why but this reminds me something of Italian public administration). This is the reason why in many cases, particularly when there are many agents, when the model is run p5 falls considerably until its minimum.

Each agent runs the procedure for each couple of goods. When the first individual has done it for every pair, the second person goes, and so on till the last one. Then, the second procedure of the "go" button, "move-turtles", runs and makes agents move to the

patch representing their x4's – the x coordinate – and utilities – the y coordinate. Agents keep running the two procedures after one another for 50 times. There will be some cases in which the economy has reached an equilibrium before the button stops: in these cases the "if" conditions of every agent are not satisfied any more, so the agents do not exchange, however they still make each confrontation until the end of the 50 times. These "times" are called "ticks", and they are used here as time beaters: 50 ticks are considered a period of time, no matter whether the conditions are satisfied.

3.2.3 The parameter k

It is now the moment to introduce one of the interesting parts of the simulation model.
All of what has been so far performed is under the assumption that k, the parameter of the utility functions that can be modified, is equal to one, thus it does not alter the intensity of satisfaction that good 4 yields, which is then entirely given by d.
The parameter k is the sum of three components: j, z and u. j is the "trend": it is equal to one, and it just describes the fact that d follows its trend, due to factors we do not want to explore here. We want instead to see what happens when there are deviations from this central value, and to do so we model the disturbance using z and u. It now is easy to see why the assumption of j being equal to one is irrelevant for our purposes:

$$k * d = (j + z + u) + d = j * d + (z + u) * d$$

and since it is the last factor that we want to analyse, the entity of j is irrelevant.
As of z and u instead, they represent the "disturbance" from the trend. In a first moment, only z takes on a value, while u remains null. We can think of z as an index summarising the effectiveness of a marketing campaign: if it is successful, z will be high and so will be the entire exponent of x4, increasing the utility attributed to it. We talk about marketing of industries instead of firms, however it does not seem wrong to us since similar goods are now so differentiated by things such as brand that we can talk about industries instead of firms, with no significant change in results.

Since the exponent of x4 must be greater than zero (increasing utility) and less than one (decreasing marginal utility), the values z can assume are those in the range (-1; 1/d – 1). When z approaches -1, it cancels j out and the exponent approaches zero: the campaign has not only been ineffective, but also counterproductive, in that it has almost nullified the utility that the person enjoys from the consumption of the good. When z is equal to zero, the campaign does not change the utility funcion of the agent; when it is greater then zero, marketing has been effective. It has to be noticed that z is different for every person, because individuals have different reactions to external stimuli, due to things like different attitudes or different moral judgments. The assignment of z occurs randomly in the specified range, and its mean value is reported in a monitor in the interface tab, so as to know, on average, what effect the campaign has had on consumers' preferences.

After z's have been assigned, the button “go again” has to be pressed. It calls the same procedures as button “go”: “find-equilibrium” and “move-turtles”, hence agents start confronting margial rates of substitutions with price ratios again, this time with a different utility function. They stop when other 50 ticks pass. In some situations an equilibrium will be reached, in others it will not.

In the following period, something new occurs: the process u starts. It can be thought of as the collateral effects that marketing brings about in subsequent moments as that of introducement of the marketing strategy, for example reactions of industries the goods of which are substitute of that produced by X4. For the same reasons as those adduced for the marketing campaign, the degree of effectiveness of the reactions is randomly chosen (the white noise shock). The process is made of two components: an autoregressive component of order 1 and a white noise term: u = ro * u' + v, where u' is the value of u of the preceding period. When the button “white noise shock” is pressed, v is assigned a value in a range chosen so as to maintain the usual properties of the utility function, taking into account that this time also the parameter z is present: the feasible span is (-1 - z; 1/d - 1 – z). Since u was zero in previous periods, now u is equal to v. When it takes on the minimum value (-1 -z), the utility of x4 is almost zero: regardless of the previous effect of the marketing campaign (be it positive or negative), now the satisfaction deriving from the good is very small. When u is (1/d – 1 – z), the exponent of x4 approaches one and its utility is very big. Since u represents a counteracting campaign, the latter case means that the reaction has not achieved the results hoped for, and has improved instead the situation of industry X4.

Afterwards, button “go again” has to be newly pressed. Agents perform their “maximisation” process with their new utility functions. After 50 ticks they stop.

The last button of the upper part of the interface tab is called “generate new period without shock”, and makes the autoregressive component of the u process advance without any new shocks. It is possible to modify the value of the correlation coefficient in the interface tab through an apposite slider called “ro”. Pressing the button, a new period is generated, with a new u equal to (ro * u). Notice that, if the button is pressed for the first time, then the new u is equal to (ro * v) because previous u is just equal to the white noise shock. Repeatedly pressing this button it is possible to generate new periods without shocks, but simply making the autoregressive component progress: since it is a converging process (ro < 1), u will gradually diminish every time it goes on, unless a new white noise is generated. In fact, there are no numbers characterising the last two buttons because they can be pressed according to the experimenter's wants. Once the first white noise has been generated, the observer can do three sorts of things: either he makes the autoregressive component run without other shocks, hence making u gradually disappear; or he can generate new shocks, without the autoregressive componet; or he can make them go together, as in a normal autoregressive process, in which the shock comes about every period. In this last case, the experimenter has to press the buttons “white noise shock”, then “go again”, afterwards “generate new period without shock” and then “go again” anew, and so on.

To sum up, we built the model in the following way. We have four phases in the model. In the first one no disturbance takes place: k is equal to the trend value j. The second sees the marketing campaign take place: z assumes some value in its range and u is zero. In the third, z remains constant, while u changes because of the white noise shock v. In the fourth, autoregression of u occurs, either with or without new white noise shocks, according to the buttons pressed.

The parameter z, defining the effectiveness of the marketing campaign upon agents preferences, is assigned randomly, is different for every agent, and has infinite persistence, unless the experimenter presses “set parameter z” another time. In this case, a new z is generated and the old one is lost.

The parameter v is a white noise. If the button generating it is pressed once only, and later (after having run “go again” once) the sole “generate new period without shock” is pressed every time we “go again”, then time after time the persistence of v upon u diminishes until it disappears and u goes back to zero: we go back to the situation in

which only z affects preferences. Of course, if ro is near one, the persistence of v will be very high and a great number of periods will be needed for u to go to zero. If instead ro is very small, the persistence will be limited to few periods.
The model could be extended by changing the persistence of z. Differently from v, z in the model has a correlation coefficient of 1: once it is generated, it stays constant. It could instead be given an autoregressive process similar to that of parameter u: since both describe the same kind of stimulus to individual preferences, the only difference being the industry from which it comes, they are likely to have similar persistance. This could be done creating a new button, with exactly the same function as "generate new period without shock", but referring to z instead of u (that is, setting z = ro * z). The persistance of z and u could also be allowed for being different: in such a case a new slider should be created to set the correlation coefficient related to z (called, say, ro1).

So far our approach has been fairly orthodox. Agents are rational: they choose the quantities to consume in a utility maximising way. There is a good in their utility functions that cannot be directly changed by agents: x5. Leisure, however, is determined by the hours of labour needed to produce the other goods, thus it is still set in a utility function framework.
The next section relaxes the assumption of completely rational agents: decisions are not only made accounting for utility, but also according to individuals' psychological patterns other than those usually defined as "rational".

3.2.4 Non rational consumption decisions

The buttons on the bottom refer to another hypothesis. Suppose people choose the quantity of a certain good to consume according to some criterion other than utility maximisation, for instance according to the cultural traits binding them. In such a case, notwithstanding the higher subjective utility people could attain by changing the quantity of the good, they keep it constant. We can think, for example, of a religious guy who has tried alchol once and liked it, but later decides not to drink any more because of

the rules of his religion. We could not say that, at the moment in which he decides not to buy alchol, he is maximising his utility because if he did not so then he would suffer from not obeying to his religion. We cannot say so because ideologies – and religions – are not a matter of utility; rather, they are part of a broader concept called psychological pattern. As Colombatto [2011] says talking about pure altruism, which is a parallel concept in that it implies people acting regardless of their utility functions:

> [...] [it] *originates from motivations created by ideology which, once accepted, become part of the individual psychological pattern. In particular, ideology affects what people understand by deontinc duty and social legitimacy: what a human being is suppose to do to fulfil his nature, and the bonds that keep individuals together in a community. [...] Psychological patterns can be affected by ideas: not only do these change the way people develop their preferences* [in our case, the trend variable j]*, but, and more importantly, they have an effect on their value judgments. [...] Failure to be altruistic* [in our case, to follow the rules imposed by the religion that you accept] *is not sanctioned, nor does it provoke pain. Instead, it is perceived as the betrayal of one's own nature.* [p. 47, 48]

We could also think of a different example of why individuals set the quantity consumed in a non maximising way, always in the field of psychological patterns, but hardly part of an ideology. Sometimes people buy some sort of goods not because they really need it, but because they follow social norms that suggest it is better to own those goods. We can think of them as "status goods", when people want to show (even when they are not) they belong to a higher income class. Particularly with new forms of payment such as division into instalments, people are led to downplay the financial burden that the purchase imposes on them, and later they are obliged to adjust the quantities of all other goods according to a new – lower – budget constraint.

Having noticed these tendencies of departure from classical utility maximisation in actual world, we tried to model them, making use of the theoretical setup typical of mainstream economics in a modified way.

Suppose individuals fix the quantity of a certain good, x4 (button "assign x4"), and do not allow for it to change, while all other goods are exchanged for one another as usual. Since x4 cannot be given up for other goods, in the "find constrained equilibrium"

procedure agents do not even calculate the marginal rates of substitution that involve x4. The other pairs of produced goods are exchanged in the same manner as in the “find equilibrium” procedure.
The chooser “cultural-trait” permits to set the range among which the new quantities of good 4 can be assigned. When it is on “religious-guy” (the interpretation is that of the first part of this paragraph) the possible interval is [1, 20], the same interval as the initial random assignment, however it comes after goods have been exchanged: very often after the reassignment x4tot decreases. When the chooser is on “status-good” instead, the range is [20, 49], and almost always x4tot increases: agents buy more of good 4 notwithstanding the optimal quantity is lower (status goods).
To better understand the rational and the functioning of the model, see the section on experiments, in which interpretations and conclusions are put forward. In the following section instead, a closer inspection to the code provides an explanation of the procedures.

3.3 The realization of the model through NetLogo

This section reports the code generating the simulation model obtained using NetLogo. NetLogo is an agent-based programming language. It is

> [...] *particularly well suited for modeling complex systems developing over time. Modelers can give instructions to hundreds or thousands of "agents" all operating independently. This makes it possible to explore the connection between the micro-level behavior of individuals and the macro-level patterns that emerge from their interaction.* [NetLogo user manual 2012]

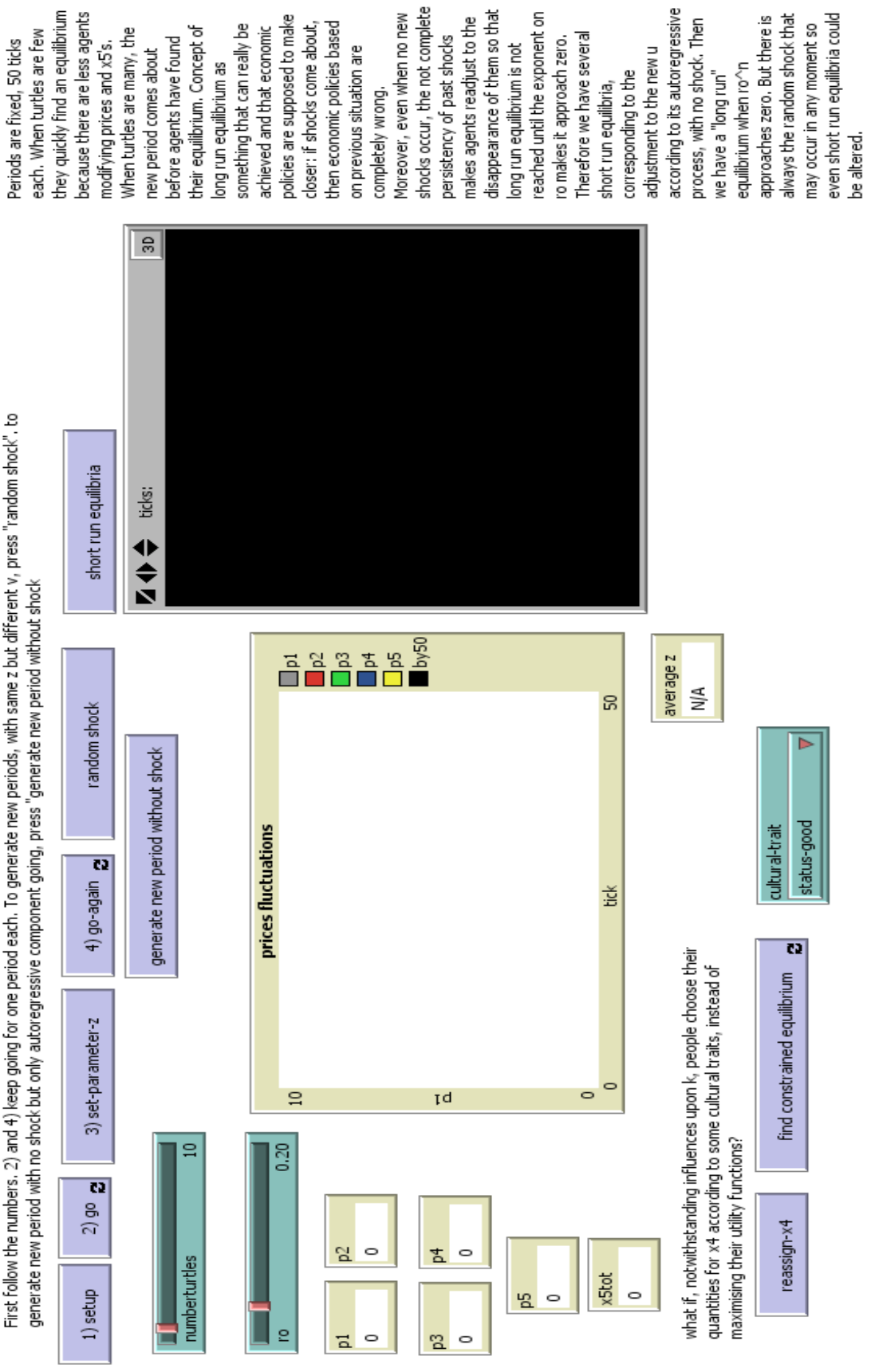
Agents are called “turtles” and can be assigned variables; they can change their variables, move around and act upon global variables (those attached to the whole

system), as well as imitate other turtles.
When NetLogo is opened, three tabs appear: “Interface”, “Info” and “Code”. The third is where the model is created through the programming language, the first is where the model is run, and the second is where it is explained how to use the model and what the purposes of it are.

3.3.1 The interface tab

In the interface tab the observer can both give inputs to the model and see the output. There is a world, provided with coordinates, where turtles are and move, there can be monitors showing results and plots where also trends appear. From the input side there can be put buttons, that make some of the procedures written on the code run; sliders, which make the observer choose among a certain range the value to assign to a variable; and many other things. To better understand their functioning, it is better to resort to a concrete example, therefore let us show how the interface tab looks like in our model: it is the figure in the next page.
On the very top, on the bottom and on the right side there are some notes where the modeler gives information to the observer. The modeler is who writes the code, while the observer is who makes the experiment, and may not know how the procedures of the code work. The sliders “numberturtles” and “ro” are the place where the observer can set the number of agents and the value of the variable ro, respectively.
Over the upper and the bottom notes there are rectangles which can be pressed and are called “buttons”. By pushing them the observer makes agent do something, and this sometimes makes turtles move in the world (the black square on the right). Over the slider “ro” there are 6 monitors: they show the values of the respective variables when the model is run. On their right there is a diagram plotting the prices pattern, however notice that the diagram could even refer to variables that are not shown in monitors.
To conclude, we have other 2 buttons on the bottom, and the chooser “cultural trait”, referring to the modification of the model in which the rationality assumption is relaxed. The chooser determines how agents behave when the two last buttons are pressed, in the

two alternative hypothesis named “religious-guy” and “status-good”.



3.3.2 The code

The code necessarily begins defining the variables that will be used. These are divided into turtles-own and globals. Turtles-own variables are different for every agent, even though they represent the same thing. For example “utility” is a variable that assumes a different value for every turtle, but whose meaning (and expression) is the same for all. The only turtle who can change its value is the one who owns it.
Globals variables are referred to the whole system: they characterise the model and can be changed by any turtle as well as by the observer (also turtles-own can be set by the observer). At the beginning of the code, the modeler has to define the variables she is going to use, so that NetLogo is ready to read the commands. Here is the beginning of our code.

3.3.2.1 Variables' definition

```
globals [

 by50

 p1      ;; price of good 1
 p2      ;; price of good 2
 p3      ;; price of good 3
 p4      ;; price of good 4
 p5      ;; price of leisure

 x1tot   ;; total quantity produced good 1
 x2tot   ;; total quantity produced good 2
 x3tot   ;; total quantity produced good 3
 x4tot   ;; total quantity produced good 4

 c1      ;; total labour cost good 1
```

```
  c2       ;; total labour cost good 2
  c3       ;; total labour cost good 3
  c4       ;; total labour cost good 4
  x5tot     ;; total leisure
  f1       ;; parameter cost function good 1
  f2       ;; parameter cost function good 2
  f3       ;; parameter cost function good 3
  f4       ;; parameter cost function good 4
  R        ;; total time endowment

  j        ;; exogenous trend of the parameter k
  n        ;; number of periods passed

]

turtles-own [
  utility       ;; utility function: same shape for everyone but different parameters
  sms12      ;; marginal rates of substitution
  sms13
  sms14
  sms15
  sms23
  sms24
  sms25
  sms34
  sms35
  sms45
  x1       ;; good 1
  x2       ;; good 2
  x3       ;; good 3
  x4       ;; good 4
  x5       ;; unused quantity of labour: leisure
  a        ;; esponent good 1
  b        ;; esponent good 2
```

```
 c       ;; esponent good 3
 d       ;; esponent good 4
 f       ;; esponent leisure
 k       ;; parameter liable of being changed by the marketing function [it refers to x4]
 z       ;; index of social norms or of effectiveness of marketing
 u       ;; autoregressive term
 v       ;; random term
 ]
```

3.3.2.2 Setup

After the definition of the variables, the procedures start. These are blocks of commands that give instructions to the turtles and are activated through buttons. The "setup" button, to begin, is made of one procedure called "setup-turtles" plus two functions whose workings are predetermined in NetLogo, "clear-all" and "reset-ticks": they both are useful when we want to make an experiment after having done one; the former clears all outcomes of the interface (it clears monitors, plots, and the world because it deletes all past values attached to variables), while the second makes ticks (see the description of button "go" to specifically see what they are) go to zero.
The setup button is then described in the code as follows. Every procedure has to begin with "to" and finish with "end".

```
to setup
  clear-all
  setup-turtles
  reset-ticks
end
```

Since "clear-all" and "reset-ticks" are predetermined, only "setup-turtles" has to be specified. . Notice that when two semicolon on a row are present, NetLogo does not consider what is written after them as a command. It thus serves to directly put comments in the code tab.

```
to setup-turtles
  set-default-shape turtles "person"
  create-turtles numberturtles [
  set label who ]

  set f1 ( 0.75)
  set f2 ( 0.75)
  set f3 ( 1.25)
  set f4 ( 1.25)
  set R (20 * 4 * count turtles)      ;; max # of each good * num goods * num turtles
  set p5 (0.01 + random-float 10)     ;; initial random prices
  set p1 (0.01 + random-float 10)
  set p2 (0.01 + random-float 10)
  set p3 (0.01 + random-float 10)
  set p4 (0.01 + random-float 10)
  set j (1)
  set n (1)

  ask turtles [
    set x1 (5 + random 16)
    set x2 (5 + random 16)
    set x3 (5 + random 16)
    set x4 (5 + random 16)
    set a (random-float 1)
    set b (random-float 1)
    set c (random-float 1)
    set d (random-float 1)
    set f (random-float 1)
    set k (j + z + u)]
  set x1tot (sum [x1] of turtles)
  set x2tot (sum [x2] of turtles)
  set x3tot (sum [x3] of turtles)
  set x4tot (sum [x4] of turtles)
  set c1 ( f1 * x1tot)                ;; cost functions
```

```
 set c2 ( f2 * x2tot + (1 / 4) * f1 * x1tot)
 set c3 ( f3 * x3tot)
 set c4 ( f4 * x4tot)
 set x5tot (R - c1 - c2 - c3 - c4)
 ask turtles [
   set x5 (x5tot / (count turtles))
   set utility  (x1 ^ a * x2 ^ b * x3 ^ c * x4 ^ (k * d) * x5 ^ f)
   setxy x4 utility
 ]
end
```

Since the working of the model has already been explained in previous sections, I will only explain the primitives used to build it. The first is very simple: set-default-shape turtles "person" just makes turtles in the world look like people. Create-turtles is self evident and numberturtles after it recalls the switch present in the interface tab: a number of turtles is created equal to what has been chosen through the switch. “Set label who” only makes every turtle show its corresponding number. If turtles are ten, for example, turtles will be labelled from 0 to 9.

Afterwards a column of “set” is present. All global variables are given a value, sometimes random, sometimes deliberately chosen by the modeler, except for x1tot, x2tot, x3tot, x4tot and x5tot, which will be set after the individual x's are assigned.

This is done within the first ask block of the code. Ask is a primitive that makes all agents, one after another in random order, do what is written in the squared parenthesis opened after it: in this case, it assigns the individual initial endowment of goods and the exponents of utility functions. It is now possible to set the values of the total production of the goods. Notice that the totals are global variables thus they can be set by the observer without asking turtles for doing it. Indeed, their setting is outside the ask block. Knowing the total amounts of goods to be produced, R (total time endowment) and the labour requirements needed to produce them, NetLogo can calculate total leisure, x5tot, and later ask turtles to take an equal number of hours of leisure each. Setup is done: the model is ready to run.

3.3.2.3 Go: First procedure

“go” is a forever button. You can see it is from the interface tab: on the bottom right corner of the button there are circular arrows. It means that NetLogo will keep running the procedures called by the button until it is not pressed again.

```
to go
  find-equilibrium
  move-turtles
  if ticks >= n * 50 [stop]
end
```

In this case it is not necessary to press it twice because of the fourth row of the part of code just reported. Ticks are the number of times that the procedure “go” is run by all turtles. When all turtles have done all the commands within “go” once, ticks will be equal to one, and so on. When all turtles have done so 50 times, the button stops. This command is given to NetLogo through the primitive “if”. The condition to be satisfied is what is written immediately after “if”, and if it is true, then the command in squared brackets is executed.
Let us now inspect the two procedures called by this button, starting from the first.

```
to find-equilibrium
  tick
  set by50 0
  if remainder ticks 50 = 0 [set by50 0.2]

  ask turtles [
   set sms12 ((x2 ^ b * a * x1 ^ (a - 1)) / (x1 ^ a * b * x2 ^ (b - 1)))
    if (p1 / p2 - sms12) > (sms12 / 10) and x1 > 1 [
      set x1 (x1 - 1)
      set x2 (x2 + 1)
      set p1 (p1 - 0.1)
      set p2 (p2 + 0.1)
    ]
```

```
 if (p1 / p2 - sms12) < (- sms12 / 10) and x2 > 1 [
   set x1 (x1 + 1)
   set x2 (x2 - 1)
   set p1 (p1 + 0.1)
   set p2 (p2 - 0.1)
   ]

set sms13 ((x3 ^ c * a * x1 ^ (a - 1)) / (x1 ^ a * c * x3 ^ (c - 1)))
 if (p1 / p3 - sms13) > (sms13 / 10) and x1 > 1 [
   set x1 (x1 - 1)
   set x3 (x3 + 1)
   set p1 (p1 - 0.1)
   set p3 (p3 + 0.1)
 ]
 if (p1 / p3 - sms13) < (- sms13 / 10) and x3 > 1  [
   set x1 (x1 + 1)
   set x3 (x3 - 1)
   set p1 (p1 + 0.1)
   set p3 (p3 - 0.1)
 ]

set sms14 (x4 ^ (k * d) * a * x1 ^ (a - 1)) / (x1 ^ a * (k * d) * x4 ^ (k * d - 1)))
 if (p1 / p4 - sms14) > (sms14 / 10) and x1 > 1 [
   set x1 (x1 - 1)
   set x4 (x4 + 1)
   set p1 (p1 - 0.1)
   set p4 (p4 + 0.1)
 ]
 if (p1 / p4 - sms14) < (- sms14 / 10) and x4 > 1 [
   set x1 (x1 + 1)
   set x4 (x4 - 1)
   set p1 (p1 + 0.1)
   set p4 (p4 - 0.1)
  ]
```

```
set sms23 ((x3 ^ c * b * x2 ^ (b - 1)) / (x2 ^ b * c * x3 ^ (c - 1)))
 if (p2 / p3 - sms23) > (sms23 / 10) and x2 > 1 [
  set x2 (x2 - 1)
  set x3 (x3 + 1)
  set p2 (p2 - 0.1)
  set p3 (p3 + 0.1)
 ]
 if (p2 / p3 - sms23) < (- sms23 / 10) and x3 > 1 [
  set x2 (x2 + 1)
  set x3 (x3 - 1)
  set p2 (p2 + 0.1)
  set p3 (p3 - 0.1)
 ]

set sms24 ((x4 ^ (k * d) * b * x2 ^ (b - 1)) / (x2 ^ b * (k * d) * x4 ^ (k * d - 1)))
 if (p2 / p4 - sms24) > (sms24 / 10) and x2 > 1 [
  set x2 (x2 - 1)
  set x4 (x4 + 1)
  set p2 (p2 - 0.1)
  set p4 (p4 + 0.1)
 ]
 if (p2 / p4 - sms24) < (- sms24 / 10) and x4 > 1 [
  set x2 (x2 + 1)
  set x4 (x4 - 1)
  set p2 (p2 + 0.1)
  set p4 (p4 - 0.1)
 ]

set sms34 ((x4 ^ (k * d) * c * x3 ^ (c - 1)) / (x3 ^ c * (d * k) * x4 ^ (k * d - 1)))
 if (p3 / p4 - sms34) > (sms34 / 10) and x3 > 1 [
  set x3 (x3 - 1)
  set x4 (x4 + 1)
  set p3 (p3 - 0.1)
```

```
  set p4 (p4 + 0.1)
 ]
 if (p3 / p4 - sms34) < (- sms34 / 10) and x4 > 1 [
  set x3 (x3 + 1)
  set x4 (x4 - 1)
  set p3 (p3 + 0.1)
  set p4 (p4 - 0.1)
 ]
set x1tot (sum [x1] of turtles)
set x2tot (sum [x2] of turtles)
set x3tot (sum [x3] of turtles)
set x4tot (sum [x4] of turtles)
set c1 ( f1 * x1tot)
set c2 ( f2 * x2tot + (1 / 4) * f1 * x1tot)   ;; cost functions
set c3 ( f3 * x3tot)
set c4 ( f4 * x4tot)
set x5tot (R - c1 - c2 - c3 - c4)
set x5 (x5tot / (count turtles))
set sms15 ((x5 ^ f * a * x1 ^ (a - 1)) / (x1 ^ a * f * x5 ^ (f - 1)))
 if (p1 / p5 - sms15) > (sms15 / 10) and x1 > 1 [
  set x1 (x1 - 1)
  set p1 (p1 - 0.1)
  set p5 (p5 + 0.1)
 ]
 if (p1 / p5 - sms15) < (- sms15 / 10)  and p5 > 1 [
  set x1 (x1 + 1)
  set p1 (p1 + 0.1)
  set p5 (p5 - 0.1)
 ]
set x1tot (sum [x1] of turtles)
set x2tot (sum [x2] of turtles)
set x3tot (sum [x3] of turtles)
set x4tot (sum [x4] of turtles)
set c1 ( f1 * x1tot)
```

```
set c2 ( f2 * x2tot + (1 / 4) * f1 * x1tot)   ;; cost functions
set c3 ( f3 * x3tot)
set c4 ( f4 * x4tot)
set x5tot (R - c1 - c2 - c3 - c4)
set x5 (x5tot / (count turtles))
set sms25 ((x5 ^ f * b * x2 ^ (b - 1)) / (x2 ^ b * f * x5 ^ (f - 1)))
 if (p2 / p5 - sms25) > (sms25 / 10) and x2 > 1 [
   set x2 (x2 - 1)
   set p2 (p2 - 0.1)
   set p5 (p5 + 0.1)
 ]
 if (p2 / p5 - sms25) < (- sms25 / 10) and p5 > 1 [
   set x2 (x2 + 1)
   set p2 (p2 + 0.1)
   set p5 (p5 - 0.1)
 ]
set x1tot (sum [x1] of turtles)
set x2tot (sum [x2] of turtles)
set x3tot (sum [x3] of turtles)
set x4tot (sum [x4] of turtles)
set c1 ( f1 * x1tot)
set c2 ( f2 * x2tot + (1 / 4) * f1 * x1tot)   ;; cost functions
set c3 ( f3 * x3tot)
set c4 ( f4 * x4tot)
set x5tot (R - c1 - c2 - c3 - c4)
set x5 (x5tot / (count turtles))
set sms35 ((x5 ^ f * c * x3 ^ (c - 1)) / (x3 ^ c * f * x5 ^ (f - 1)))
 if (p3 / p5 - sms35) > (sms35 / 10) and x3 > 1 [
   set x3 (x3 - 1)
   set p3 (p3 - 0.1)
   set p5 (p5 + 0.1)
 ]
 if (p3 / p5 - sms35) < (- sms35 / 10) and p5 > 1 [
   set x3 (x3 + 1)
```

```
    set p3 (p3 + 0.1)
    set p5 (p5 - 0.1)
   ]
  set x1tot (sum [x1] of turtles)
  set x2tot (sum [x2] of turtles)
  set x3tot (sum [x3] of turtles)
  set x4tot (sum [x4] of turtles)
  set c1 ( f1 * x1tot)
  set c2 ( f2 * x2tot + (1 / 4) * f1 * x1tot)   ;; cost functions
  set c3 ( f3 * x3tot)
  set c4 ( f4 * x4tot)
  set x5tot (R - c1 - c2 - c3 - c4)
  set x5 (x5tot / (count turtles))
  set sms45 ((x5 ^ f * (d * k) * x4 ^ (k * d - 1))/ (x4 ^ (k * d) * f * x5 ^ (f - 1)))
   if (p4 / p5 - sms45) > (sms45 / 10) and x4 > 1 [
    set x4 (x4 - 1)
    set p4 (p4 - 0.1)
    set p5 (p5 + 0.1)
   ]
   if (p4 / p5 - sms45) < (- sms45 / 10) and p5 > 1[  ;; justified by minimum wage
    set x4 (x4 + 1)
    set p4 (p4 + 0.1)
    set p5 (p5 - 0.1)
   ]
 ]
end
```

The first line, “tick”, just makes this variable increase by one unit each time the two procedures are run by all turtles, as already observed.

by50 is just an instrumental variable to make the plot mark a black spike when 50 ticks have passed, and since 50 ticks are a period in our model, it beats the time. This is done through the fourth line of the procedure: if the remainder of the division between the number of ticks and 50 is zero, by50 assumes value 0.2 and a black mark appears in the plot.

At this point, the main ask block of the model is defined. It makes turtles compare their marginal rates of substitutions with the price ratios and then increase or decrease the consumption of the goods according to what increases their utility, as previously described in the section “A simulation model using NetLogo”. I will now explain how primitives have been used to reproduce the maximisation problem.

All following instructions are within the ask block, thus they will be entirely run by the turtles before the next one starts. For each pair of goods, first of all, the marginal rate of substitution (sms) is calculated and assigned. NetLogo cannot be asked to calculate a derivative, so we have to write down the expressions. When the pair contains good 5 (leisure), the marginal rate of substitution contains x5, and we have to recalculate its value because it may have changed as a consequence of previous exchanges: if the labour requirement to produce the new mix has changed, this will affect the hours of leisure available. NetLogo does not link a variable with an expression, but only gives the value resulting from it. When the variables within the expression change it will be necessary to make NetLogo recalculate the value and reset the variable.

Then the price ratio is compared with the respective marginal rate of substitution : there is a “if” followed by a “and”. It means that if both conditions are satisfied than the commands in squared brackets are executed. The conditions, when good x5 is not involved, are: the difference between price ratio and sms has to be significant (more than a tenth of the sms), and the quantity of the good whose marginal utility is lower has to be greater than one. This second condition is needed to guarantee that the variable utility does not become null. If both are true then the turtle gives up one good for the other (she changes her turtles-own x's) and modifies prices, in the same direction as the market would do, by 0.1 (she changes global variables). If one condition is not satisfied, or both, she does nothing.

All four commands in brackets push sms and price ratio closer, therefore the conditions tend to become false when the procedure is run many times by the agent. However, the trend is disturbed by the other turtles running and changing prices.

When good 5 is that with the lower marginal utility, the second condition changes, because x5 cannot be changed by agents thus it is not possible for them to directly run it down in the commands of the “if” primitive; it becomes the following: p5 has to be greater than 1. It is a very realistic assumption since the price of leisure is the wage rate and nowadays in most advanced countries there is a lower limit for legal salaries. However, it is also an important condition for the model not to incurr in an error. Since

turtles cannot directly decrease x5 when its marginal utility is low, and since the indirect change is by less than one, then it is more difficult for sms and price ratio to align. Therefore, the condition tends to be true more often and p5 could be decreased below zero.

3.3.2.4 Go: Second procedure

The second procedure of "go" is move-turtles.

```
to move-turtles
  set x1tot (sum [x1] of turtles)
  set x2tot (sum [x2] of turtles)
  set x3tot (sum [x3] of turtles)
  set x4tot (sum [x4] of turtles)
  set c1 ( f1 * x1tot)
  set c2 ( f2 * x2tot + (1 / 4) * f1 * x1tot)   ;; cost functions
  set c3 ( f3 * x3tot)
  set c4 ( f4 * x4tot)
  set x5tot (R - c1 - c2 - c3 - c4)
  ask turtles [
  set x5 (x5tot / (count turtles))
  set utility  (x1 ^ a * x2 ^ b * x3 ^ c * x4 ^ (k * d) * x5 ^ f)
  setxy x4 utility
  set label (word who ";" int utility)
   ]
end
```

This procedure makes turtles recalculate x5 with the purpose of getting the new value of "utility" and making turtles move to the patch representing their x4 (x axis) and utility (y axis). Moreover, a new label is attached to turtles, showing, other than their number, the value of utility.

3.3.2.5 Set parameters, go again

```
to set-parameter-z
  set n (n + 1)
  ask turtles [
    set z (-0.99 + random-float 1 / d)   ;; since k has to be in the range [0.01 , 1/d]
    set k (j + z + u)                                ;; and j is 1
  ]
end
```

Turtles set randomly, in a range such that the entire exponent of x4 mantains the property of utility functions, the value of z.
n is a variable used to make forever buttons go on by 50 ticks every time they are pressed: it augments by 1 when a new parameter is set. Remember the condition for "go" to stop: if ticks >= n * 50 [stop] so when n is one the button stops at 50 ticks, when n is 2 at 100, and so on. It is just a trick to make forever buttons stop by themselves when the period has passed.

```
to set-parameter-v
  set n (n + 1)
  ask turtles [
  set v (-1 - z - ro * u + random-float 1 / d)
  set u (ro * u + v)
  set k (j + z + u)
  ]
end
```

The available range is different this time because we have to take into account the value of z.

```
to generate-period-without-shock
  set n (n + 1)
  ask turtles [
  set u (ro * u)
```

```
  set k (j + z + u)
  ]
end
```

Here only the autoregressive component of u advances.

```
to go-again
  find-equilibrium
  move-turtles
  if ticks >= n * 50 [stop]
end
```

This procedure calls the two procedures already called by the button “go”. It is not necessary to write them again because they had already been defined in the code. This time, however, turtles run them with the new assigned values of the changed parameters.

```
to short-run-equilibrium
  set n (n + 10000)
end
```

This procedure has the only scope of making n very large, so that the forever buttons do not stop for a long time, and it will be needed to stop them manually. It is used in a separate experiment, with the purpose of letting turtles complete their maximisation each time a parameter has changed, so that in the interface tab it is shown the situation of hypothetical equilibrium that would occur if shock came only after all adjustments are done.

3.3.2.6 Reassign x4, find constrained equilibrium

```
to reassign-x4
  set n (n + 1)
  ask turtles [
```

```
    ifelse cultural-trait = "religious-guy"
     [set x4 (1 + random 20)]
     [set x4 (20 + random 20)]
  ]
end
```

“ifelse” is a primitive similar to “if”, but with two commands: that in the first brackets indicates what has to be done when the condition is true (in this case, if the chooser is set on “religious-guy”), while that in the second is run when the condition is false (the chooser is set on “status-good”). In particular, when it is true, the new values of x4 are in the range [1, 20], and when it is false the new values will be within [20, 39].

Finally, the last button recalls move-turtles and a new procedure:

```
to go-with-x4-fixed
  move-turtles
  find-constrained-equilibrium
  move-turtles
  if ticks >= n * 50 [stop]
end
```

The new procedure is just the same as previously defined find-equilibrium but with the pairs involving x4 omitted, because of the hypothesis that the button allows to test.

```
to find-constrained-equilibrium
  tick
  set by50 0
  if remainder ticks 50 = 0 [set by50 0.2]
  ask turtles [

   set sms12 ((x2 ^ b * a * x1 ^ (a - 1)) / (x1 ^ a * b * x2 ^ (b - 1)))
    if (p1 / p2 - sms12) > (sms12 / 10) and x1 > 1 [
      set x1 (x1 - 1)
      set x2 (x2 + 1)
```

```
  set p1 (p1 - 0.1)
  set p2 (p2 + 0.1)
 ]
 if (p1 / p2 - sms12) < (- sms12 / 10) and x2 > 1 [
  set x1 (x1 + 1)
  set x2 (x2 - 1)
  set p1 (p1 + 0.1)
  set p2 (p2 - 0.1)
  ]

set sms13 ((x3 ^ c * a * x1 ^ (a - 1)) / (x1 ^ a * c * x3 ^ (c - 1)))
 if (p1 / p3 - sms13) > (sms13 / 10) and x1 > 1 [
  set x1 (x1 - 1)
  set x3 (x3 + 1)
  set p1 (p1 - 0.1)
  set p3 (p3 + 0.1)
 ]
 if (p1 / p3 - sms13) < (- sms13 / 10) and x3 > 1  [
  set x1 (x1 + 1)
  set x3 (x3 - 1)
  set p1 (p1 + 0.1)
  set p3 (p3 - 0.1)
 ]

 set sms23 ((x3 ^ c * b * x2 ^ (b - 1)) / (x2 ^ b * c * x3 ^ (c - 1)))
 if (p2 / p3 - sms23) > (sms23 / 10) and x2 > 1 [
  set x2 (x2 - 1)
  set x3 (x3 + 1)
  set p2 (p2 - 0.1)
  set p3 (p3 + 0.1)
 ]
 if (p2 / p3 - sms23) < (- sms23 / 10) and x3 > 1 [
  set x2 (x2 + 1)
  set x3 (x3 - 1)
```

```
  set p2 (p2 + 0.1)
  set p3 (p3 - 0.1)
 ]

set x1tot (sum [x1] of turtles)
set x2tot (sum [x2] of turtles)
set x3tot (sum [x3] of turtles)
set x4tot (sum [x4] of turtles)
set c1 ( f1 * x1tot)
set c2 ( f2 * x2tot + (1 / 4) * f1 * x1tot)   ;; cost functions
set c3 ( f3 * x3tot)
set c4 ( f4 * x4tot)
set x5tot (R - c1 - c2 - c3 - c4)
set x5 (x5tot / (count turtles))
set sms15 ((x5 ^ f * a * x1 ^ (a - 1)) / (x1 ^ a * f * x5 ^ (f - 1)))
 if (p1 / p5 - sms15) > (sms15 / 10) and x1 > 1 [
  set x1 (x1 - 1)
  set p1 (p1 - 0.1)
  set p5 (p5 + 0.1)
 ]
 if (p1 / p5 - sms15) < (- sms15 / 10)  and p5 > 1 [
  set x1 (x1 + 1)
  set p1 (p1 + 0.1)
  set p5 (p5 - 0.1)
 ]
set x1tot (sum [x1] of turtles)
set x2tot (sum [x2] of turtles)
set x3tot (sum [x3] of turtles)
set x4tot (sum [x4] of turtles)
set c1 ( f1 * x1tot)
set c2 ( f2 * x2tot + (1 / 4) * f1 * x1tot)   ;; cost functions
set c3 ( f3 * x3tot)
set c4 ( f4 * x4tot)
set x5tot (R - c1 - c2 - c3 - c4)
```

```
 set x5 (x5tot / (count turtles))
 set sms25 ((x5 ^ f * b * x2 ^ (b - 1)) / (x2 ^ b * f * x5 ^ (f - 1)))
  if (p2 / p5 - sms25) > (sms25 / 10) and x2 > 1 [
    set x2 (x2 - 1)
    set p2 (p2 - 0.1)
    set p5 (p5 + 0.1)
  ]
  if (p2 / p5 - sms25) < (- sms25 / 10) and p5 > 1 [
    set x2 (x2 + 1)
    set p2 (p2 + 0.1)
    set p5 (p5 - 0.1)
  ]
 set x1tot (sum [x1] of turtles)
 set x2tot (sum [x2] of turtles)
 set x3tot (sum [x3] of turtles)
 set x4tot (sum [x4] of turtles)
 set c1 ( f1 * x1tot)
 set c2 ( f2 * x2tot + (1 / 4) * f1 * x1tot)   ;; cost functions
 set c3 ( f3 * x3tot)
 set c4 ( f4 * x4tot)
 set x5tot (R - c1 - c2 - c3 - c4)
 set x5 (x5tot / (count turtles))
 set sms35 ((x5 ^ f * c * x3 ^ (c - 1)) / (x3 ^ c * f * x5 ^ (f - 1)))
  if (p3 / p5 - sms35) > (sms35 / 10) and x3 > 1 [
    set x3 (x3 - 1)
    set p3 (p3 - 0.1)
    set p5 (p5 + 0.1)
  ]
  if (p3 / p5 - sms35) < (- sms35 / 10) and p5 > 1 [
    set x3 (x3 + 1)
    set p3 (p3 + 0.1)
    set p5 (p5 - 0.1)
  ]
]
```

end

In the next section some examples of experiments, with different hypothesis, are run, and explained together with some conclusions we can draw from them.

3.4 Some examples of experiments

3.4.1 Experiment 1: first steps, 2 turtles

Purpose

Understanding the working of the basic model

Setup

number turtles = 2

Run

Press buttons 1) to 4):

1) setup: variables are assigned. In particular, turtles-own variables are: initial quantities of goods [x1, x2, x3 and x4 randomly; x5 as a consequence], utilities [utility], parameters of utility functions [a, b, c, d, f, k, j].
   Global variables are: cost functions, total time endowment [R, depending on the

number of turtles, so as to have 80 hours/week for each agent], prices [p1, p2, p3, p4, p5 randomly].

2) go. Two procedures: find-equilibrium and move-turtles. Stop after 50 ticks. Find equilibrium: turtles exchange goods on the basis of the confrontation of their marginal rates of substitution with price ratios. Prices change accordingly. x5's are reassigned each time other quantities are changed.Move-turtles: recalculate, for each turtle, x5 [since last turtle of previous procedure has changed quantities] and utility; move turtles on the patch representing their x4 [x axis] and utility [y axis].

3) set parameter z. z is given a value in a range such that utility finctions' basic properties are satisfied. k is recalculated.

4) go again. Two procedures: find-equilibrium and move.turtles. Stop after 50 ticks. Same as “go” but for clarity of the sequence to be pressed another button has been created.

3.4.1.1 Outcome of point 2)

p1 = 6.45021
p2 = 6.95728
p3 = 8.48633
p4 = 6.76715
p5 = 4.32265

Table 1.1: Outcome of point 2)

Turtle	Utility	x4	k * d
0	135.392	10	0.35124
1	91812.835	18	0.84614
Total	**91948,227**	**28**	**1.19738**

[Notice that k * d is here simply equal to d because k is only influenced by its trend j equal to 1.]

Turtle 1 has a d significantly higher than Turtle 0. It means that the utility she derives from 4 is much higher. Also the other exponents of the utility function of Turtle 1 are far higher that those of the other agent: all of them are above 0.8, except for b which is 0.4. Turtle 0's exponents are instead all below 0.4, except for f which is 0.67. The magnitude of Turtles' f is the reason why p5 does not fall very much (to see why it is expected to fall, see the paragraph “go” in a previous section of this chapter): being f high, the marginal utility given by leisure is so great for every agent that their sms15, sms25, sms35 and sms45 are often smaller than the respective price ratios, thus x1, x2, x3 and x4 are not incremented when confronted with x5 (hence not reducing x5) and p5 does not fall.

3.4.1.2 Outcome of point 4)

p1 = 6.45021
p2 = 7.05728 ↑
p3 = 8.48633
p4 = 6.56715 ↓
p5 = 4.42265 ↑

Table 1.2: Outcome of point 4)

Turtle	Utility	x4	k * d	z
0	993.491	24	0.87513	1.49151
1	9150.635	2	0.10364	-0.87751
Total	**10144.126**	**26**	**0.97877**	**Average 0.307**

Here (k * d) is equal to (j + z) and j is always 1.

Turtle 0's z is very high: the marketing campaign has been greatly effective, making the exponent of x4 go from 0.35124 to 0.87513. This makes her marginal utility of x4 much greater than before, and consequently the "find-equilibrium" procedure makes her increase the quantity of x4. As a result, Turtle 0's utility has soared.

On the contrary, Turtle 1's z is negative and high in module. This almost nullifies the great d that this turtle has, sinking the exponent of x4 to 0.10364: being the marginal utility of good 4 much lower than before, the new equilibrium value for the quantity of the good becomes 2, much lower than previous 18.

By looking at prices it is easy to see what happened. Only p2, p4 and p5 changed in the new equilibrium. This means that, if x1 and x3 of the two turtles have changed, then there must have been an exact match between the units given up by one turtle and those aquired by the other, and vice versa. This is confirmed by the plot of p1 and p3, showing some disturbance after tick 50, subsequently eliminated. What is more important for our purposes is that p4 has decreased by 0.2: the fall of Turtle 1's x4 (-18) has been bigger than Turtle 0's increase of the same variable (+16). Since p2 and p5 have increased by 0.1 each, one unit of 4 must have been exchanged for a unit of 2 and the other must have been dropped with no exchange, increasing the hours of leisure available to both agents.

Notice that the average z is 0.307, a positive number. This means that, on average, the marketing campaign has been effective in terms of higher intensity of preferences: the good influence on utility functions' parameters has been greater than the bad. However, results show that x4tot has actually decreased: the marketing industry has been counterproductive in terms of the quantity sold. This is so because the effect of z on the whole exponent of x4, (k * d), depends on the value of d: if d is high, then the effect of z is amplified; when d is low, it is relatively small. In this example, even though the average z is positive, the sum of (k + d)'s of turtles is less than what it was before.

In real life only quantities are checked out to assess whether a campaign has been effective. If they remain constant, however, because of what has just been showed, we cannot conclude that people's preferences towards the good have not been changed.

3.4.2 Experiment 2: high ro, 10 turtles [random-seed 2]

Purpose

Understanding the working of the economy when labour market is not perfect
Understanding the meaning of the concept “equilibrium”
Assessing how the system behaves in the presence of conscious – rather than rational – choices

Setup

number turtles = 10
ro = 0.8

Run

A) Press buttons 1) to 4):

1) setup. Variables are assigned. In particular, turtles-own variables are: initial quantities of goods [x1, x2, x3 and x4 randomly; x5 as a consequence], utilities [utility], parameters of utility functions [a, b, c, d, f, k, j]. Global variables are: cost functions, total time endowment [R, depending on the number of turtles, so as to have 80 hours/week for each agent], prices [p1, p2, p3, p4, p5 randomly].
2) go. Two procedures: find-equilibrium and move-turtles. Stop after 50 ticks.
   Find equilibrium: turtles exchange goods on the basis of the confrontation of their marginal rates of substitution with price ratios. Prices change accordingly. x5's are newly computed each time other quantities are changed.
   Move-turtles: recalculate, for each turtle, x5 [since last turtle of previous

procedure has changed quantities] and utility; move turtles on the patch representing their x4 [x axis] and utility [y axis].

3) set parameter z. z is given a value in a range such that utility finctions' basic properties are satisfied. k is recalculated.
4) go again. Two procedures: find-equilibrium and move-turtles. Stop after 50 ticks. Same as "go" but for clarity of the sequence to be pressed another button has been created.

B) Press "random shock": v is given a value in a range such that utility finctions' basic properties are satisfied. k is recalculated.

C) Press "go again": two procedures again. Find-equilibrium: this time agents redo their maximisations with the new k comprending also u [this first time entirely given by v]. Move-turtles: turtles are relocated according to their new values of x4 and utility.

D) Press "generate new period without shock": the autoregressive component of u takes place, with no additional random shock. Being ro high, in this case, u will be not very different from case B). k is recalculated.

E) Press "go again": two procedures again. Find equilibrium: agents do their maximisation again with the new k, given by j, z and the 80% of v.

F) Redo D) and E) until equilibrium is reached: since ro is 80%, the new final equilibrium, corresponding to the situation in which u is zero, will be reached after relatively many times.

G) Set the switch on the desired "cultural trait", then press "reassign x4". Agents are assigned random quantities of good 4.

H) Press "find constrained equilibrium": agents redo the maximisation, without considering good 4. Individuals are still rational for goods 1, 2 and 3, but they do not act "rationally" [i.e. maximising the utility function] for what regards good 4: they decide upon it on the basis of psychological patterns other than utilitarian

considerations.

3.4.2.1 Outcome of A) 2)

p1 = 5.39498

p2 = 4.97207

p3 = 4.68307

p4 = 3.67984

p5 = 2.40754

Tabella 2.1: Outcome of point A) 2)

Turtle	Utility	x4	k * d
0	435.191	15	0.76749
1	1634.168	10	0.74877
2	344.875	9	0.41973
3	183.341	9	0.35367
4	199.229	6	0.21463
5	773.827	41	0.24717
6	1169.646	22	0.73674
7	4519.577	41	0.58000
8	620.474	5	0.32287
9	1648.014	12	0.91447
Total	**11528.3**	**170**	**5.30559**

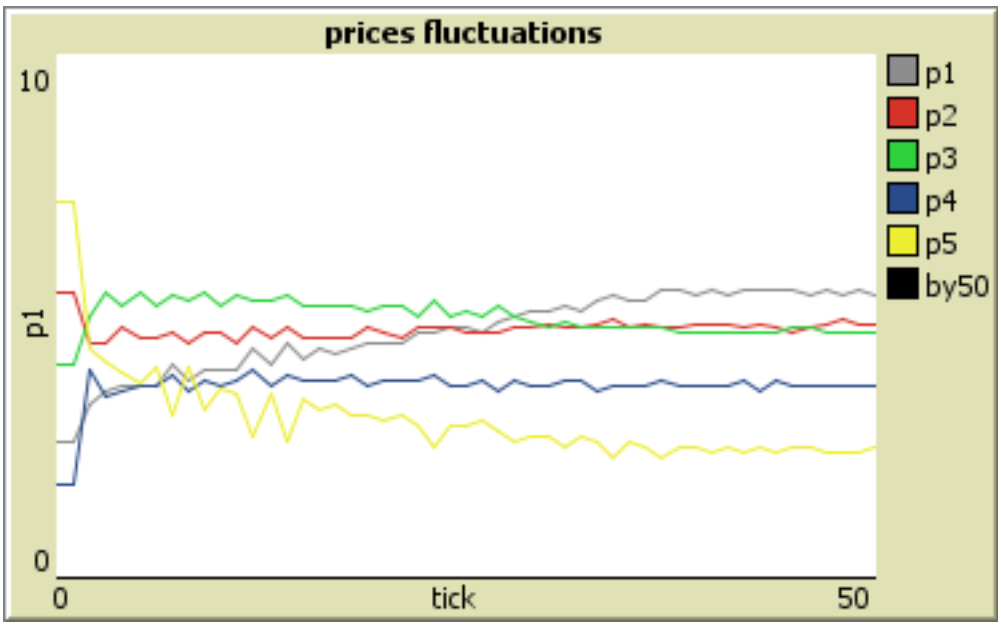
[Notice that k * d is here simply equal to d because k is only influenced by its trend j equal to 1.]

Turtles 5 and 7 have a great quantity of good 4, more than twice as big as the maximum endowment allowed for by the setup button. This is possible, first of all, because of the large number of turtles: if they are many, in the random giving out process there is a

considerable probability that some agents are “very poor”, that is, they have a poor good endowment. As a consequence, the x5's of agents are aboundant and their marginal utilities low. (Remember that the total time endowment is initially set so as to permit the production of the maximum quantities that the random process can assign, and remember also that individual leisure hours are all identical and equal to x5tot, the number of hours left after all goods have been produced, over the number of turtles.) This makes the marginal rates of substitution between each other good and leisure relatively high, thus the quantities of other goods will be increased and p5 and (indirectly) x5's diminished.

Moreover the greater number of turtles makes prices more volatile because there are more agents influencing them: more stimuli also lessen the possibility for one specific agent to impact price ratios, therefore decreasing the extent to which the discrepance between her marginal rate of substitution and the price ratio shrinks at every round, and lengthening the path towards equilibrium.

Figure 2.1: Prices fluctuations after the first 50 ticks



As we can see from figure 2.1, prices fluctuations are still present at the end of the period: the “big” adjustments occur until tick 25 for prices of 2 to 5, while p1 keeps increasing until the last decade of ticks, to reach a stable range of values then. All prices cannot reach their short run equilibrium, however they oscillate around it within a small

interval.

Notice the sharp decrease of p5: this is expected, particularly when agents are many, because x5 cannot be directly changed by them. When their marginal rates of substitution between any of the other goods and leisure is greater than the relevant price ratio, then they increase the quantity of the other good, making its marginal utility decrease; p5 is decreased and the other price increased. x5 falls indirectly because of the rise of the units of the good to produce, however it only decreases by one tenth of the production cost of the additional unit, because total leisure is shared by workers. This means that the marginal utility of x5 increases very slowly, and the discrepancy between the marginal rate of substitution and price ratio will be levelled out after many times the confrontation is done: p5 falls, the price of the other good rises.

3.4.2.2 Outcome of point A) 4)

p1 = 5.79498 ↑

p2 = 5.27207 ↑

p3 = 5.08307 ↑

p4 = 2.27984 ↓

p5 = 2.70754 ↑

Tabella 2.2: Outcome of point A) 4)

Turtle	Utility	x4	k * d	z
0	311.775	19	0.55831	-0.27254
1	904.78708	10	0.39396	-0.47386
2	530.690	17	0.44956	0.07107
3	113.357	5	0.10488	-0.70344
4	373.050	16	0.34203	0.59357
5	457.277	33	0.11357	-0.54050
6	262.280	14	0.27478	-0.62702
7	1377.185	33	0.25833	-0.55459
8	512.232	5	0.18575	-0.42467
9	252.445	4	0.19796	-0.78352
Total	**5095.083 ↓**	**156**	**2.87918**	**Average -0.37155**

The marketing campaign has been promoted, and its effects summarised by the values of the parameter z. Notice that the campaign has been fairly counter-productive from the point of view of preferences: the exponent of good 4 has been diminished in 80% of cases. This time the result in terms of quantity and price of good 4 is consistent with the analysis of utility functions: both p4 and x4tot have decreased. Other industries are happy with industry X4's action: by doing nothing, they saw their prices soar and their quantities not diminish.

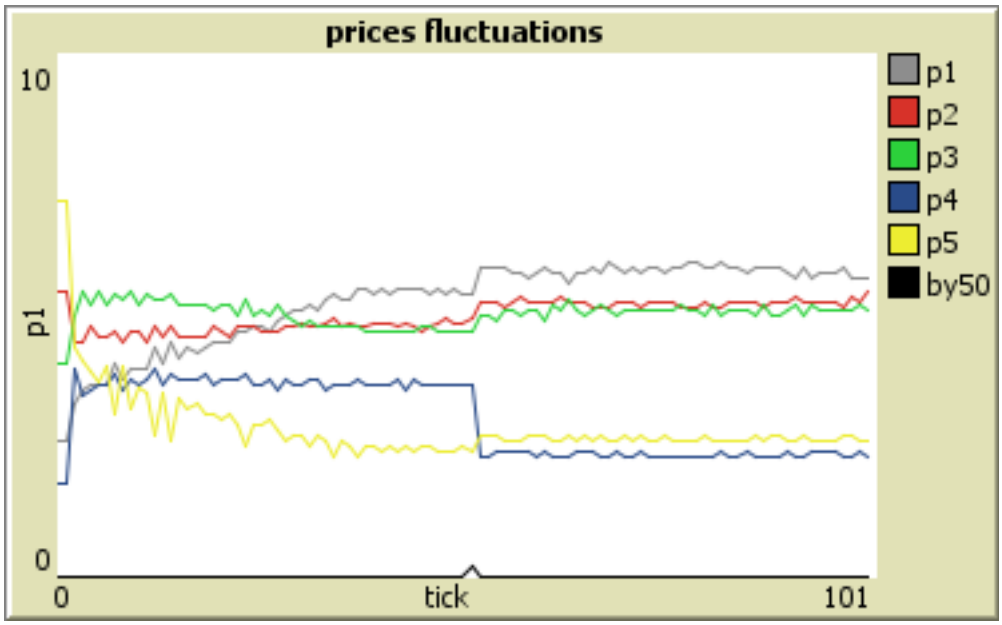
Consumers, instead, are not quite happy. The sum of their utilities has more than halved. To be fair, this alone does not mean that society as a whole is worse off, because it could be that there has been a redistribution and people prefer to be more equal with minor aggregate utility than having bigger inequality with great sum of utility. The preferences of the society can be resumed in the social welfare function, putting together individual's utilities according to the meaning we assign to the word “welfare”. If utilities of individuals are just added up, it means that society does not care about inequality, and just aims at maximising total utility.

On the other extreme, if the social welfare function is of the “Rawlsian” type (SWF = min (utilities)), then society utterly cares about equality: nothing but the utility of the poorest matters. Other functions can describe middle-way situations, in which both distribution and total utility are important, think for example of a social welfare function of the same form as the utility functions of our model, with individual utilities instead of quantities of goods: being individual marginal utility decreasing, making a poor better off is valued more than increasing a rich's welfare, but also the total matters.

In our example, without specifying any form of social welfare function, we can definitely conclude that the campaign has had a negative effect on consumers: only two turtles, 2 and 4, saw their utilities increase, while all the others have seen their economic welfare dramatically lowered (turtle 9, for example, passed from 1648.014 to 252.445).

This is due to the lower utility agents assign to good 4, and in minor degree to the lessened quantity consumed of this good. An interpretation could be the following: individuals have not appreciated the marketing campaign, on the contrary it made their satisfaction deriving from the good decrease, however they still find it optimal to buy it, but in minor quantities, and with significantly lowered utility.

Figure 2.2: Prices fluctuations after the second 50 ticks



The black line peak shows the time at which the campaign has been introduced: the effect on prices has been sharply negative for good 4 and slightly positive for all other goods.

3.4.2.3 Outcome of point C), random shock

p1 = 5.09498 ↓
p2 = 4.47207 ↓
p3 = 4.38307 ↓
p4 = 4.87984 ↑
p5 = 2.30754 ↓

Industries X1, X2 and X3 may want to make the most of this opportunity and try to design an action, by learning from X4's failure, that points to amplifying its effects. However, the outcome is subject to the same uncertainty as the original marketing campaign: this is why we talk about random shock. In this first experiment, the shock occurs only in a first period, and later it gradually disappears following the autoregressive process defined by ro and not disturbed by any subsequent shock. This

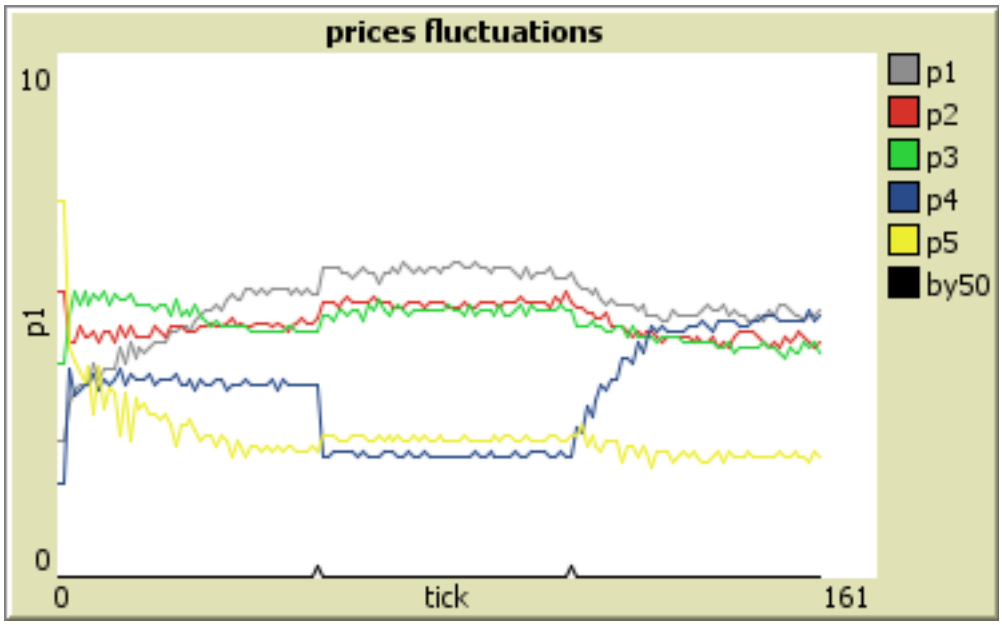
section refers to the first period, in which the reaction of the other industries is introduced: u is here just equal to v.

From table 2.3 we notice that u is negative for 4 turtles and positive for 6, and the average is slightly positive. This is a good effect from the X4's standpoint, not so from other industries' vantage point. Remember that the effect of parameters z and u on marginal utilities heavily depends on the values of d, therefore, even though the average were positive, the effect on the sum of (k * d)'s may well be a decrease. However, this is not the case. For turtles 5, 6 and 1 the positive shock has been massive: they alone account for almost 3 of the 4.5 points of the total value of (k * d). This total has not a direct economic meaning, however it serves us to summarise the total changes in x4's exponents, avoinding us to separately consider every d and every effect of z and u upon such exponents. We conclude that the reaction of industries 1, 2 and 3 has been counter-productive for them, while it has improved X4's situation. This is confirmed by prices' pattern.

Table 2.3: Outcome of point C)

Turtle	Utility	x4	k * d	u
0	71.870	4	0.25799	-0.39129
1	2233.870	9	0.89559	0.66993
2	135.046	1	0.00796	-1.05209
3	83.381	2	0.16737	0.17668
4	239.489	6	0.35238	0.04821
5	28210.495	111	0.96784	3.45608
6	2156.877	20	0.96805	0.94098
7	3025.629	27	0.54429	0.49302
8	329.543	1	0.01125	-0.54046
9	165.920	1	0.15473	-0.04727
Total	**36652.125**	**182**	**4.50274**	**0.37537**

Figure 2.3: Prices fluctuations after third 50 ticks



3.4.2.4 Outcome of point E), first autoregressive period

p1 = 5.19498 ↑
p2 = 4.67207 ↑
p3 = 4.38307
p4 = 4.47984 ↓
p5 = 2.40754 ↑

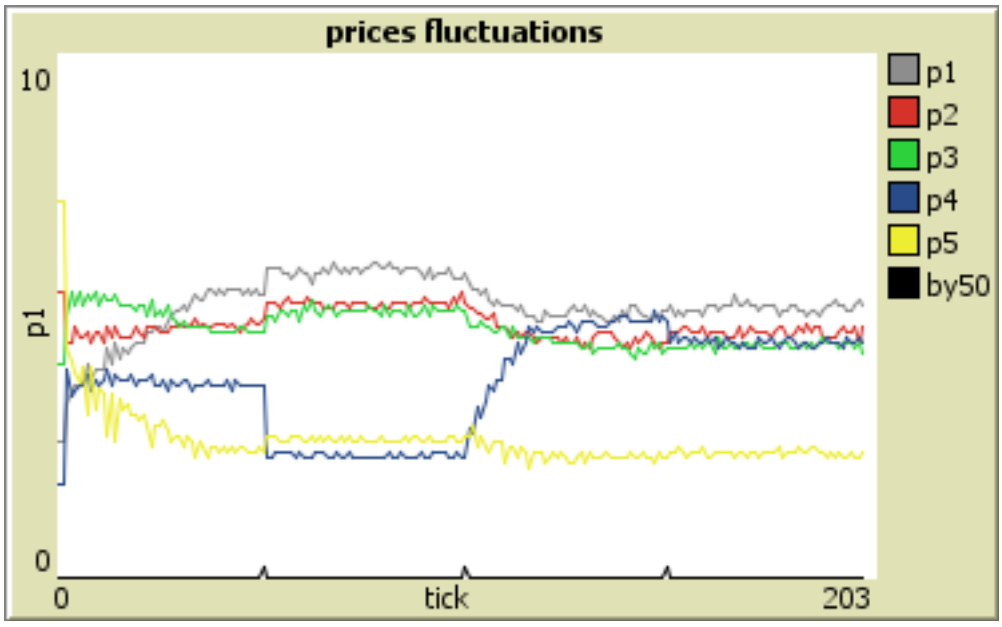
In the first autoregressive period of this example we have a u equal to the 80% of that of the previous period, while z, by hypothesis, remains unchanged. An interpretation could be that the original marketing campaign has been very incisive, and consumers remember of it, and behave according to its effects, for a long time. It is possible to extend the model and relax this assumption, allowing for a gradual "forgetting" of the campaign, just by giving z an autoregressive process similar to that of u, but with a very high ro, such as 0.98 or so. The timing of this process should be the same as that of u, because the time span that the utility functions take to evolve should be the same. In this case, the long run equilibrium at which the model would tend would be the same as that of step 2), but the short run equilibria would be different from our present case. The interesting thing to see would be whether turtles could reach the short run equilibria to which they tend each period, and under what circumstarces they could because, as we will see later, in the the experiment which is being described here, they almost always cannot. The achievement of short run equilibria in the case in which also z is not perfectly persistent could be facilitated or delayed: it is not completely predictable what would be the causes of the two different possibilities.
The purpose of this experiment, however, is to see, when an incisive (read: whose effects are persistent) campaign has been introduced, what happens if the reaction from the environment, be it from other industries or popular movements of ideological reaction, shuffle cards with a persistance less than perfect. This is represented by the parameter u and its process determined by ro and its fixed time of implementation, 50 ticks.
Returning to our experiment, as it was described in the paragraph called "Run", button E) is pressed several times, making the autoregressive process of u take place. All endogenous variables undertake a converging path towards an equilibrium that is exactly equal to that to which they tended when the value of u was 0, that is, before the button

“random shock” had been pressed. The interesting thing to see is what happens in the several “short runs” that occur. Periods, equal to 50 ticks, beat the time of the u process, that is, the time that utility functions take to “forget” the reaction to the campaign.
During every period u is unchanged, and the system tends to a short run equilibrium which is different from the long run one, since this last has a u equal to zero.
Are turtles able to reach their short run equilibria before the periods end? We could have set the buttons “go” and “go again” as a forever buttons, and just indicate to stop them when all lines are flat. However, it would have made no sense, because the timing at which shocks and the unfolding of u's process take place is indipendent of the attainment of equilibrium. We thus gave a reasonable timing to the process and then asked ourselves whether a stable situation could be reached within them.
To see how the short run equilibria look like, it is possible to run the model with the same steps, but pressing the button “short run equilibria” after “setup”. By doing so, the “go” and “go again” will keep going until they are stopped, hence you will have to press them again when you see the plot showing flat lines: each time they become so, the short run equilibrium has been reached and you can see from the monitors its characteristic values. These are what turtles tend to during each period of the normal model, and they are reached sometimes very quickly, sometimes very slowly. Notice that here you make the random shock take place and the process u go on only when all variables reach their temporarily stable values, while in the experiment parameters are changed when these variables have different values: this implies a difference in the impact of the change induced through the buttons affecting the parameters, thus the path towards equilibrium.
Let us now go back to our experiment and see what actually happens in this case with respect to the first short run equilibria.
First of all, we see from table 2.4 that variables have not changed much, as expected: 80% is a high percentage for an autoregressive process. More interesting is figure 2.4: prices have not reached an equilibrium before the end of the period, notwithstanding the fact that u has not changed by much. In fact, since this is the only variable liable of being changed from previous period, and since it is very close to last period's one, we thought that the short run equilibrium would have had more probability than previous periods to be reached. However, this did not happen.

Table 2.4: Outcome of point E), first autiregressive period

Turtle	Utility	x4	k * d	u
0	91.313	5	0.31806	-0.31303
1	1814.396	9	0.79526	0.53594
2	110.608	1	0.09628	-0.84167
3	99.327	3	0.15487	0.14134
4	266.733	7	0.35031	0.03857
5	12287.109	105	0.79698	2.76486
6	1372.544	19	0.82939	0.75278
7	2512.194	27	0.48710	0.39442
8	333.483	1	0.04615	-0.43237
9	168.073	1	0.16337	-0.03781
Total	**19055.784**	**178**	**4.03782**	

Figure 2.4: Outcome of point E), first autoregressive period



By trying several times the same experiment with different ro, we found that, even though the fluctuations become narrower in range, short run equilibria of the first autoregressive periods can almost never be reached within the periods. Ten agents cannot be considered a large number, particularly if this number is confronted with those

characterising our population. We are thus led to think that short run equilibria are very unlikely to be reached in real world.

3.4.2.5 Outcome of point E), after several autoregressive periods

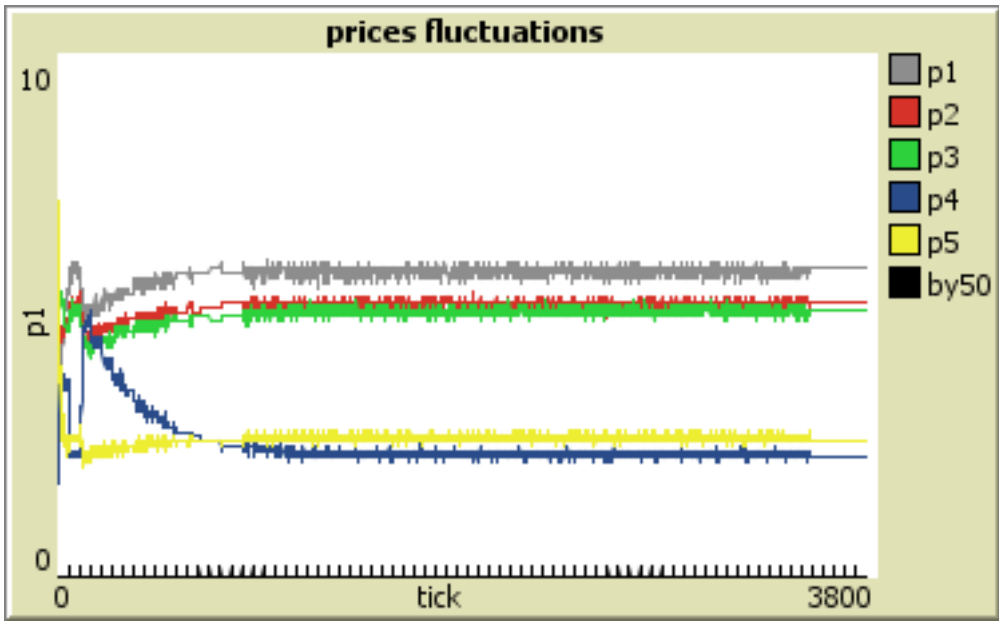
Going on with the periods of autoregression in the main experiment, we record that during 4th and 9th period lines are flat, while in 1st to 10th they keep oscillating. After the 11th, short run equilibria are reached every time, however prices keep changing from a period to the following, adjusting towards the long run situation: this is found by pressing many times "generate period without shock". It is interesting to see the long run prices:

p1 = 5.89498 ↑ by 0.1
p2 = 5.27207
p3 = 5.08307
p4 = 2.27984
p5 = 2.60754 ↓ by 0.1

The arrows compare this with the outcome of button A) 2). As you can see, things are not perfectly equal. This is so becaue during the process bringing u back to zero some approximations are done by agents. I do not think that this is an error of the model. On the contrary, in real world many and even bigger approximations are performed by people: utility functions are a useful analytical tool but they do not exist in reality. Common people do not even now what a derivative is: they behave as if they new it but it is the researcher that assigns the function to describe people, not people that try to behave as the researcher describes. Therefore, it is the mathematical maximisation that approximates reality, not vice versa.
To briefly sum up this part of the experiment, we found that short run equilibria are almost never reached, and that the new long run equilibrium, after a shock has been implemented and then dissolved through time, can be different from how it was before the shock.
It is possible to run a variant of the same experiment, by allowing the shock to occur in every period. It is necessary in this case to press "random shock" at the beginning of

each period, without pressing “generate new period without shock”. The new u will be equal to its autoregressive component plus a new random shock. In this case, there is no long run equilibrium to be reached, because every period something new occurs. The alleged equilibrium to which the economy, according to mainstream economics, is supposed to tend does not exist.

Figure 2.5: Outcome of point E) after more than 50 periods



3.4.2.6 Outcome of point H) find constrained equilibrium

The button “reassign x4” makes agents be reassigned a value of x4, and “find constrained equilibrium” makes them redo the maximisation problem with only 3 goods liable of being changed. The rational is the following.

Suppose people choose the quantity of a certain good to consume according to some criterion other than utility maximisation, for instance according to the cultural traits binding them. In such a case, notwithstanding the higher subjective utility people could attain by changing the quantity of the good, they keep it constant. We can think, for example, of an religious guy who has tried alchol once and liked it, but later decides not

to drink any more because of the rules of his religion. We could not say that, at the moment in which he decides not to buy alchol, he is maximising his utility because if he did not so then he would suffer from not obeying to his religion. We cannot say so because ideologies – and religions – are not a matter of utility; rather, they are part of a broader concept called psychological pattern.

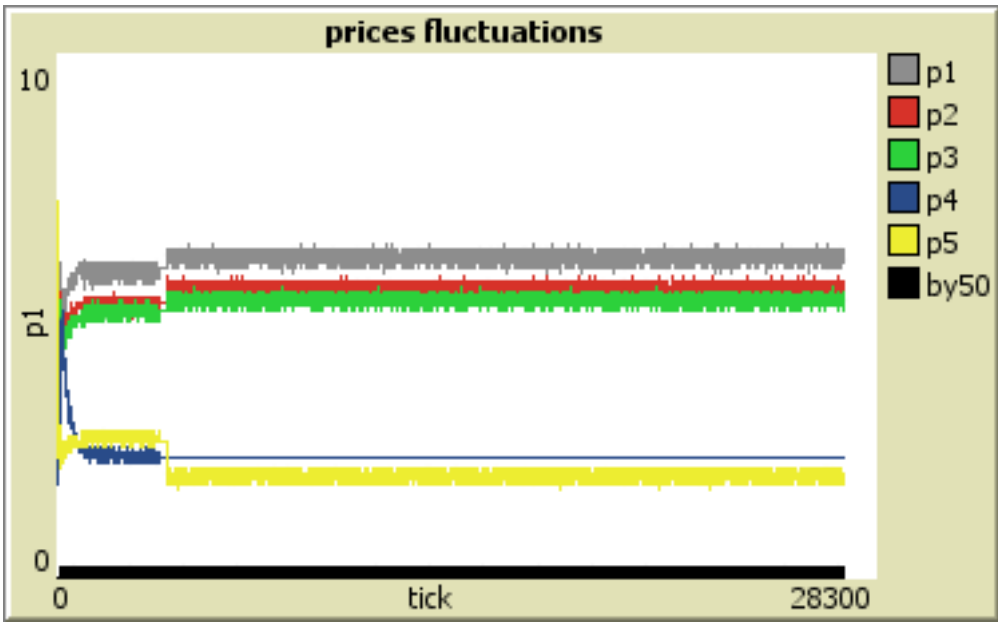
We could also think of a different example of why individuals set the quantity consumed in a non maximising way, always in the field of psychological patterns, but hardly part of an ideology. Sometimes people buy some sort of goods not because they really need it, but because they follow social norms that suggest it is better to own those goods, irrespective of the budget constraint. We can think of them as "status goods", when people want to show (even when they are not) they belong to a higher income class. Particularly with new forms of payment such as division into instalments, people are led to downplay the financial burden that the purchase imposes on them, and later they are obliged to adjust the quantities of all other goods according to a new – lower – budget constraint. In this experiment, the budget constraint is given by the time endowment.

Let us see the long run values of prices, resulting from pressing in this order "reassign x4", "short run equilibria" and "find constrained equilibrium", while letting the chooser "cultural-trait" on "religious-guy": in this case, the new values of x4 are within the range [1, 20]. First of all, notice that a perfect equilibrium cannot be reached even after 28300 ticks, that is, 490 periods after button "find constrained equilibrium" has been pressed: utility maximisation is disturbed by the presence of choices that prescind from it. Short run equilibrium becomes an even further mirage, let alone in the 50 ticks period.

p1 = 6.09498 ↑
p2 = 5.47207 ↑
p3 = 5.28307 ↑
p4 = 2.27985
p5 = 2.00754 ↓

All prices are higher except for p5, the wage rate or price of leisure, and x4, that does not change since no further exchange takes place. It has to be noticed that the exponents of x4 are the same as those in table 2.4: the campaign and the reaction have had their impact on utility functions, but people do not consider it when establishing x4.

Figure 2.5: Outcome of button H) find constrained equilibrium: religious guy



These exogenously set x4's amount to 100 in total, that is, less than what would be if people followed their utilities only (think of the religious guy case): the labour requirement needed to produce x4tot is lower. Therefore, at the beginning of the "find-constrained-equilibrium" procedure, agents have a higher x5. This is what we meant by saying that the budget constraint changes as a consequence of decisions taken without accounting for utility. In the case of the religious guy, in which culture makes agents buy less of certain goods, the result is higher budget constraint, allowing for a greater quantity of other goods available for purchase.

Let us now tackle the opposite situation, that in which the existence of some "status goods" makes people buy them in greater amounts than what would be optimal according to their utility functions. This hypothesis is simulated through the switch "cultural-trait" set on "status-good", which changes the range in which the new values of x4 are chosen: it becomes now [20, 40]. x4's of most agents are higher than those shown in table 2.4: people buy a quantity of good 4 that is higher than what their utilities show they need. I am now thinking of goods such as Sky subscriptions, iphones, or other things that are very common to be seen in the hands of people who do not even know how to use them, thus attach to them a importance that goes beyond utility.

After points A) to F) have been run, put the switch on "status good" then press "reassign x4", "short run equilibrium" (we are interested in the stable situation) and finally "find constrained equilibrium". The outcome of this experiment (remember it is referred to

random-seed 2) is an error: «math operation produced a non-number, called by procedure “move-turtles”, called by button “find constrained equilibrium”». “Non-number” means the number is either too big or too small for NetLogo. In particular, the reason of this error is that x5's have become so small that NetLogo cannot calculate x5 to the power of f (f is smaller than zero). Conversely to the case of the religious guy, here agents buy more goods than what they can afford: the system cannot sustain this situation.

This experiment highlights an important issue: when utility functions are not the only thing on which individuals base their choices, then, not only a stable equilibrium is more difficult to be reached, but also the budget constraint tends to be neglected.

3.4.3 Experiment 3: thought experiment on social norms

Another experiment is called forth by another interpretation of the model. z represents now social norms: the persistence is exogenous, as well as the values, given by reasons apart from economic considerations. Social norms are the same for all agents, but the ways in which they impact people's psychological patterns are different. We can think of drugs: social norms say they are dangerous and bad. Some people just follow social norms by not using drugs (not even asking themselves why), some others abuse of them just because it is transgressive or unconventional (only to go against the society), thus going against the norm, and some others take the hints that social norms provide and then decide by their owns. Hence, for what regards social norms' influence on utility functions, we can set a different z for every agent, even representing something that is equal for all components of society. When the social norm changes, then all reactions to it change, and so does every z.

u represents instead norms at the law level: they can be changed through marketing campaigns or lobbying activities, however the impact of such activities upon utility functions cannot be controlled (random shock) by who implements them. Their persistence can instead be controlled by the experimenter, through the parameter ro, and

the fact that it is smaller than one stands for the difference between social norm and law: the latter is less persistent, thus social norms eventually prevail.

We could run experiment 2 with this interpretation. One of the conclusions grasped from it was that the long run equilibrium, if that means something, can slightly be changed by the occurrence of shocks. Hence, according to this interpretation, even in the so called "long run", when their influence on people's behaviour disappears, norms at the law level modifiy the outcome of the economy, even though they do not modify the building blocks of people's preferences – those given by social norms, z. The deviation is very small (we talk about a minimal difference in some prices), and is given by the presence of approximations in the find equilibrium procedure. However as we said this is not an approximation of reality because in real world no perfect maximisation is performed. On the contrary, I think that the typical mathematical maximisation is an approximation of reality, which is not perfect. Hence, the economy is sensible to actions trying to modify norms at the law level.

A second conclusion of experiment 2 is that this economy hardly comes to equilibrium before another shock occurs. Being the shock a modification of law-level norms in this case, then the presence of this kind of disturbance to the effect of social norms on utility functions makes the equilibrium more difficult to attain. Other than marketing campaigns and lobbying, also economic policies are norms, and we can definitely say they are not part of social norms: they are at the law level. Therefore economic policies, instead of moving the economy closer to a stable situation, may push further away the moment of equilibrium achievement.

Conclusions

The two theoretical chapters offered an assessment of different views about the ability of the market to bring about the best allocation of resources. In the first one, a fairly socialist opinion is presented. In the second, free-market sustainers are protagonist.

The third chapter features a simulation model where there are consumers provided with utility functions, which are maximised with some constraints. Let us review the basic properties of the system. First, the process of maximisation is not perfect: agents do not completely equalise their marginal rates of substitution with price ratios. They make the comparison to take decisions, which result in changed quantities and prices, but a divergence is allowed to remain. Second, there is an industry whose production function is partly affected by another industry's output. Third, utility functions can change as a consequence of the action of firms. Fourth, there is the possibility of allowing agents to be “non rational”, in the sense of non utility-maximising, for what regards the consumption of a good. Lastly, the model is provided with some notion of time, beaten by individuals' actions.

Using this model it is possible to simulate a variety of situations, and we selected some experiments to be exposed. We pointed out that the concept of equilibrium in a complex environment is not very useful; rather, it is desirable to explain reality in a way able to take account of the ever-changing nature of the world, and agent-based programming languages could be used to simulate individual choices driven by reasons other than utility maximisation, where equilibrium-seeking analytical tools play little role, but where the understanding of researchers can be reproduced.

In our model only a rough – although very useful – representation of non maximising behaviour has been put forward. Future developments could improve the description of actual individuals, and the resulting complication of the model would surely deliver interesting results.

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