Priorities for Backlog of Criminal Cases Pending in Courts: A Computational Agent-based Model

LUIGI BONAVENTURA, ANDREA CONSOLI*

SUMMARY: *1. Introduction – 2. An Analysis of the Justice System in Literature – 3. The Model Set-up – 4. The Simulation of the Model – 4.1. With a Low-productivity Function – 4.2. With a High-productivity Function – 5. Conclusions*

1. INTRODUCTION

The practice of establishing criteria of priority for reducing the backlog of trial procedures has been widespread for some time, although not always made clear. In both investigating and judging departments, the limited resources available have made organizational decisions necessary in order to answer the need to improve the justice system.

With reference to the Public Prosecutor's office, this subject has often led in Italy to animated discussions on the consistency of such criteria with the principle of compulsoriness of penal action, since the decision regarding which cases to bring before the court, whether made by those responsible for the offices or by the single Public Prosecutor, represents in any case a concession to discretionary power. Moving from the nineties, in any case, public and previous priorities stand out in investigation and prosecution, as in the US experience of *guidelines*: at first, with local ventures of chief prosecutors; later, with court sentences (see Disciplinary decision No. 105/97 of *Consiglio Superiore della Magistratura* - the Italian Council of Judiciary). In spite of mandatory prosecution the budget constraint of investigation has necessarily led to the use of guidelines connected to the seriousness of the crime and concrete injury resulting from behaviour.

Possibly less at the centre of the Italian political debate, but equally important for its consequences, is the definition of criteria of priority operated by the judging offices. Increasing the immediacy of a judicial reaction to crime constitutes an important instrument, adding to the deterrent effect and the social value of repression. A series of guidelines exists in these offices (since it is communicated to the Ministry of Justice) containing the criteria of assignment among the different sections according to the topic

* L. Bonaventura is assistant professor and A. Consoli is post-doc researcher at the University of Catania (Italy), Department of Economics and business.

and a criterion for the internal assignment of cases among the different magistrates in each section. It is simply left to the discretion of the individual judge to organize his own order of hearings; only in certain circumstances is this shared by means of protocols established together with the Councils of the Order of Attorneys and with the legal associations.

A recent investigation carried out by Eurispes[1], in agreement with the Union of Criminal Chambers, represents the first study of an organic nature on how criminal hearings are organized, contributing to a clearer definition of the reasons why a criminal case appears to be paralyzed by bureaucracy and formalities which offer no guarantee of a high standard of efficiency. This investigation brought to light that the average duration of proceedings is 226 days, while the average time spent in court hearing is only 18 minutes for a trial celebrated before a monocratic judge (i.e., single judge) and 52 minutes for one celebrated with a panel of judges. A little over two-thirds of the cases (69.3%) each brief considered is remanded for a further hearing for physiological reasons (prosecution of the debatement inquiry, deferment for discussion, etc.) or pathological ones (logistic problems, absence of the judge, impediment of the parties, absence of a summons or failure to appear of witnesses, etc.). The average length of deferment is 139 days for trials taking place in a monocratic court and 117 days for a panel of judges. The percentage of full hearing trials celebrated in ordinary proceeding is 90.6% while 9.4% are celebrated in alternative proceeding (5.4% in abbreviated form, 4% by settlement)[2].

In the light of these data, it is easy to understand the need to introduce criteria of priority in organizing the hearing sessions. An important step in this direction was taken by the so-called "security package"[3], whose effectiveness however has never yet been tested by the competent authorities. With the explicit aim of speeding up the reply of the court system to the request for penal justice, the measure in fact establishes that in the drawing up of schedules for the hearing and debate of cases, absolute priority must

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[1] EURISPES, *Rapporto sul processo penale in Italia*, Roma, 2008.

[2] Monitoring in the Court of Catania has revealed that the average duration of a hearing and debatement trial is only ten minutes before a monocratic judge, while with a collegiate panel of judges the time dedicated to the investigative debate is 21 minutes. In 93.9% of the cases an ordinary trial procedure is adopted, in 2,9% an abbreviated procedure and in 3.2% a settlement. Delays and postponements represent the typical outcome of hearings with average delays of 149 days for a monocratic judge and 113 days for a panel of judges.

[3] Law No. 125 of 2008, in Art. 2-*bis* regarding some modifications of the enacting, coordinating and transitory rules of the code of criminal procedure.

be ensured for certain types of crime considered particularly serious and belonging to categories considered socially dangerous, as well as for those for which a term of imprisonment of not less than four years is foreseeable. The same measure assigns to the directors of the judging offices the task of adopting criteria of priority in debating procedures and in the drawing up of hearing schedules, on the basis of the concrete offensiveness of the crime. In other words, it is as if the legislator had aimed to build a social cost function for every type of crime, considering most harmful to the interest of collective society the more serious crimes (or those of a specific type) and the most recent ones. If, in fact, the social cost is connected with the threatened penalty (which constitutes the predetermination of public interest to repression) and with the length of time necessary for the procedure to be completed and the penalty carried out, the result is that a timely repression of the more serious and more recent crimes adds to the deterrent effect and reduces the social costs of crime.

This paper takes the before mentioned "security package" as a starting-point with the purpose of analyzing the effect on the reduction of cases pending and on the lower social cost deriving from the application of the different criteria of priority. Some categories of crime consistent with those included in the package are analyzed in order to simulate the management of the backlog of cases pending of a monocratic judge who finds it necessary to organize his calendar using various criteria of priority in dealing with the cases assigned to him.

The paper is organized as follows: Section 2. contains an analysis of the relevant literature and the theoretical framework of reference; in Section 3. the structure of the model is described; in Section 4. the results of the simulation are presented; Section 5. contains the conclusions.

2. AN ANALYSIS OF THE JUSTICE SYSTEM IN LITERATURE

Economic analysis of criminal jurisdiction, more than civil jurisdiction, has not yet moved in a widespread fashion towards evaluating the productivity of its structures. Also the data processing centres and the specific departments within the Ministry of Justice often limit their activity in this field to the collection of statistical data and the creation of generalized indicators of the quality of the services offered[4]. Similarly, in literature, a univocal

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[4] Among these, the so-called *Dashboard Procedure* adopted in 2001 with which it was decided to apply to the judicial sector some quantitative modelling techniques of the back-

methodology has not been defined for assessing the efficiency of the justice systems, or for the single organizational units of which it is made up. Various techniques of economic analysis of law have been widely used to form both a theoretical and an empirical assessment of some proposals for the reform of the justice system. Attention has been focused, for example, on the length of waiting time determined by the single trial institutions in different judicial realities[5]. With reference to the penal system alone, a more systematic picture of the process is supplied by Easterbrook[6]: this author uses a marginalistic approach comparing public decisions in favour of safeguarding civil rights and liberties on the one hand and crime deterrence on the other, to define the trial as a combination of constraints and incentives in which the weight of the threatened punishment must be balanced against the private and social value of the crime committed.

A number of works on the subject of efficiency in judicial decisions have been published over the last fifteen years[7]. All these authors have aimed to define a series of indicators of assessment of the various values underlying every trial procedure.

Italian authors have focused more on exploring Court management with the aim to extend to judicial productivity some more typically economic

log of pending cases in order to assess the effects of every potential change in the organization. The *Progetto Strasburgo*, see http://www.qualitapa.gov.it/index.php?id=794&tx_wfqbe_pi1%5Buid%5d=1459, is more recent and still under development, and is coordinated for Italy by the Tribunal of Turin.

[5] See W.M. LANDES, *An Economic Analysis of the Courts*, in "Journal of Law and Economics", Vol. 14, 1971, n. 1, pp. 61-107; W.M. RHODES, *The Economics of Criminal Courts: A Theoretical and Empirical Investigation*, in "The Journal of Legal Studies", Vol. 5, 1976, n. 2, pp. 311-340; R.A. BOWLES, *Economic Aspects of Legal Procedure*, in Burrows P., Velijanovski G., "The Economic Approach to Law", London, Butterworths, 1981; G.M. GROSSMAN, M.L. KATZ, *Plea Bargaining and Social Welfare*, in "The American Economic Review", Vol. 73, 1983, n. 4, pp. 749-757; R. ADELSTEIN, J.M. MICELI, *Toward a Comparative Economics of Plea Bargaining*, in "European Journal of Law and Economics", 2001, pp. 47-67.

[6] F.H. EASTERBROOK, *Criminal Procedure as a Market System*, in "The Journal of Legal Studies", Vol. 12, 1983, n. 2, pp. 289-332.

[7] M. KOSMA, *Measuring the Influence of Supreme Court Justices*, in "The Journal of Legal Studies", Vol. 27, 1998, p. 333; W.M. LANDES, L. LESSING, M.E. SOLIMINE, *Judicial Influence: Citation Analysis of Federal Courts of Appeals Judges*, in "The Journal of Legal Studies", 1998, n. 27, pp. 272-332; S.J. CHOI, G.M. GULATI, *Choosing the Next Supreme Court Justice: An Empirical Ranking of Judicial Performance*, in "Southern California Law Review", Vol. 3, 2004; S.A. LINDQUIST, F.B. CROSS, *Measuring Judicial Activism*, Oxford, Oxford University Press, 2009; S. GOLDBERG, *Judging for the 21st Century: A Problem-solving Approach*, Ottawa, National Judicial Institute, 2005.

criteria of evaluation[8] or on the ratio between performance of the judicial administrative system and levels of entrepreneurship[9]. Still less systematic is the study of qualitative profiles of the judicial product and its characteristics.

The political debate has also concentrated on inefficiencies reported in the judicial system, and the undesirable negative record that Italy holds for its critical sentences pronounced by the European Court of Human Rights is often linked to a supply which is under-dimensioned with respect to demand. The result of this, as for every other excess of demand, should lead to the definition of some corrective measures, to an increase in supply[10] or to a system for filtering demand[11].

In order to respond also to the growing public interest in the efficiency of jurisdiction, some legislative measures[12] have attributed to the Italian National Institute for Statistics - ISTAT, as well as the usual function of data collection, also the task of elaborating methods for measuring costs and results, based on the reconstruction of standards to be determined also on the basis of cross-section observations.

3. THE MODEL SET-UP

The model adopted simulates the desk of a criminal judge, on which are placed a number of procedures, divided according to the type of crime featured. Three distinct categories of crime are considered, distinguished on the basis of their gravity and of the maximum penalty to be expected. In

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[8] L. MARINI, *Gli indicatori di efficacia ed efficienza nell'amministrazione della giustizia*, in "Rivista trimestrale di scienza della amministrazione", 2000, n. 2, pp. 143-168; G. GUARDA, *La qualità del servizio giustizia: la "lista di controllo" realizzata dalla CEPEJ*, in "Quaderni di giustizia e organizzazione", Vol. 4, 2009, n. 5, pp. 85-111; L. LEPORE, *Efficienza, efficacia ed equità nell'amministrazione della giustizia*, in "Azienda pubblica", Vol. 22, 2009, n. 3, pp. 429-448.

[9] M. BIANCO, S. GIACOMELLI, *Efficienza della giustizia e imprenditorialità: il caso italiano*, in "Economia e politica industriale", Vol. 31, 2004, n. 124, pp. 89-111.

[10] It would be possible to increase supply by employing more resources, with a more costly spending policy. Nevertheless, this is not an obvious choice for the public decider to make: collective resources are limited, while collective needs are potentially limitless.

[11] It is theoretically not difficult to limit demand, unless this is done by means of a massive de-penalization since, in general, the levels of demand are physiological: it increases with an increase in population and with the complication of social relations. Moreover, further measures which may be considered an appreciable instrument for containing demand could be represented by instruments alternative to jurisdiction.

[12] Starting from the Legislative Decree No. 29 of 1993.

relation to each type of crime three groups (populations) of procedures are defined: *red* (N_r), *yellow* (N_y), and *green* (N_g), on the judge's desk, in order of severity ($r > y > g$). This system reproduces the model of a queue, and as such is defined by:

 – a process of arrivals of the procedures (the mathematical model of which is known);
 – an accumulation buffer, represented by the judge's desk;
 – a process of service or a function of reduction of the backlog of cases pending;
 – a flow of concluded procedures exiting from the system (a statistic description of which is obtained).

The diagram in Figure 1 shows the structure of the model, where the procedures N_i enter the system and are piled up on the judge's desk. He then deals with the queue following a criterion of priority (*Pr*) and generating an output flow (*S*).
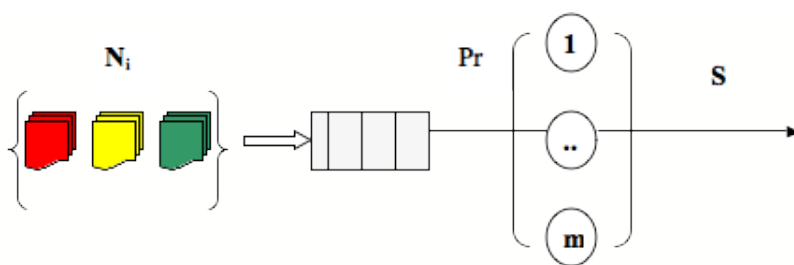

Fig. 1 – Flowchart of the model

Simplifying the operation in order to underline only the most important features of the problem analyzed, a single judge's desk (server) is shown, on which the number of new cases added is expressed by a rate (λ_i) different for each category of crime. The productivity function of reducing the backlog of cases pending is constant over time and irrespective of the type of procedure; it selects the population according to the criteria of priority adopted, and, within this group, on *FIFO* (First In, First Out) criterion. We define:

$N_i(t)$ number of procedures of the ith population in time t.

$\lambda_i(t)$ rate of arrival per time unit of the population i.

In the simulation two functions will be used for the reduction of the backlog of proceedings per time unit (with $t = 1$ day) with high (v_h) and

low (v_l) productivity. This choice is justified by the analysis of Coviello and colleagues[13] in which it is observed that in the labour sections of the Tribunals of Milan and Turin the total duration of trials can vary between the quickest judges and the slowest ones by as much as twice the rate.

Many other factors, besides the efforts of the magistrate, are involved in determining this rate of elimination of trials, such as the number of hearings necessary to close a case, the number of cases active at the same given moment and, as we aim to prove in this study, also the criterion of priority adopted by the judge in reducing the cases pending. The functions of elimination of the backlog are therefore:

$$v_h(t) = (\frac{1}{2}n_i) \cdot t$$

$$v_l(t) = (\frac{1}{5}n_i) \cdot t$$

In a period of time $h \in [0, t]$ we will obtain $\lambda_i N_i(t)h$ new arrivals for the population N_i and $v(h)$ procedures dealt with.

So the difference in the overall number of procedures in a time interval h will be:

$$N(t+h) - N(t) = \sum_{i=r,y,g} \lambda_i N_i(t)h - v(h)$$

Dividing by the time passed h we have an overall rate of growth of all the procedures present in the system:

$$\frac{N(t+h) - N(t)}{h} = \sum_i \lambda_i N_i(t) - \upsilon$$

We assume that $\sum_i N_i(t)$ varies continually, in other words it may assume all the real values. This type of hypothesis is reasonable when the population consists of a large number of procedures. We may pass on to the limit for h which tends towards 0:

$$lim_{h \to 0} \frac{N(t+h) - N(t)}{h} = N'(t) - \upsilon = \sum_i \lambda_i N_i(t) - \upsilon$$

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[13] D. Coviello, A. Ichino, N. Persico, *Giudici in affanno*, in "Annuario di diritto comparato e studi legislativi", 2009.

Given $\epsilon = \sum_i \lambda_i$ the total rate of growth of the populations, it is possible to verify that the equation (first order linear differential) has as its solutions all the functions $N(t) = ke^{\epsilon t} - \upsilon$, for $k \in \mathbb{R}$. In particular, if the population at time t_0 consists of $N(t_0)$ individuals, its evolution with time is given by the solution:

$$N(t) = N(t_0)e^{\epsilon(t-t_0)} - \upsilon$$

If $\epsilon > \upsilon$, that is if the number of new cases arriving is higher than the number of cases dealt with, the population suffers an exponential growth. But if $\epsilon < \upsilon$, the number of procedures on the waiting list will diminish rapidly.

Finally, the model evaluates the social cost of the system, by means of a function weighting the different types of crime in relation to the sentence expected (γ) and to the time it remains in the system. The procedures of the population N_r have an expected sentence equal to γ_r, those of the population N_y have an expected sentence of γ_y and finally those of the population N_g have an expected sentence of γ_g (where $\gamma_r > \gamma_y > \gamma_g$).

The social cost function has the following form:

$$\Pi_t = \sum_{t=0}^{\infty}(n_{it}\,t_i) \cdot \gamma_j$$
$$j, i \in (r, y, g)$$

4. THE SIMULATION OF THE MODEL

The simulation was carried out on NetLogo[14] on the basis of the ISTAT data for the years 2004-2005 regarding the Tribunal of Catania. In the initial situation, the judge uses the *FIFO* criterion, that is, the cases which arrive first on his desk are dealt with first, regardless of the gravity or extension of the crime. Following the most recent legislative orientations the effects of other criteria of priority will be simulated. Applying the priority of *gravity*, the cases concerning the most serious crimes (with expected penalties of 4 or more years) will be dealt with first, while procedures for less serious offences will go to the bottom of the list. Applying that of *diffusion*, the crimes that are most widespread over the territory will be selected first. In this latter case, the judge will give priority to the procedures regarding the most widespread crimes and/or those with the highest rates of growth.

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[14] The code is available from the Authors on request.

Social, economic and cultural variables, first of all, determine the composition and number of crimes committed in a given area. As well as by these variables, they are also influenced in a considerable way by the deterrent function of the entire system of repression and punishment adopted by the Authorities. In this perspective, the choice of the criterion of priority applied by the judge assumes a role that is by no means secondary. By choosing the *gravity* criterion of the crime, for example, he will speed up the procedures regarding the more serious crimes and "signal" to the (criminal) world at large that he is paying more attention to this type of crime, increasing the probabilities of reaching a sentence (and a punishment) in a short time.

Given the populations and the relative growth rates, the judge may choose the criterion of priority with which to deal with each single case. The simulation was carried out with the use of the three criteria: *FIFO*, *gravity* and *diffusion*.

Using the ISTAT data contained in Table 1 with regard to the crimes of handling stolen goods (r), fraud (y) and harm to persons or goods (g), reported to the Judicial Authorities (JA), the rate of arrival for each category of crime was estimated in the time unit and they were divided by the number of judges present in the section[15]. The model was simulated over a period of one year ($t = 365$).

	harm (g)	fraud (y)	handling (r)
2004	4122	1081	2090
2005	4833 (+17,2%)	1155 (+6,8%)	2108 (+0,8%)

Tab. 1 – Crimes reported (and % variation) to the Tribunal of Catania for which the JA has undertaken penal action [Source: ISTAT (2004-2005)].

4.1. With a Low-productivity Function

In this example the number of cases arriving on the judge's desk ($\sum \lambda_i N_i$) is higher than the number of cases dealt with, given by the function of elimi-

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[15] Four criminal sections are present in the Tribunal of Catania, each of which consisting of six judges (excluding the president). Dividing the flow of entry of proceedings by the number of judges, we obtain the rate of growth for each crime for each judge: $\lambda_r(t) = 0.068$; $\lambda_y(t) = 0.0086$; $\lambda_g(t) = 0.172$.

nation $[v_l(t) = (\frac{1}{5} n_i) \cdot t]$ resulting in a progressive accumulation on the desk of all the categories of crimes and therefore an increase in the social cost. Table 2 presents a synthesis of the percentage variations in the number of cases for each choice criterion.

	fraud	handling	harm	total	social cost
FIFO	8,9	0,7	15,2	10,6	7,4
Gravity	4,5	0,3	17,2	10,6	6,2
Diffusion	6,7	0,3	15,4	9,8	6,4

Tab. 2 – Percentage variations in the number of procedures and the social cost. Simulation with ($\sum \lambda_i N_i > v_h$).

It may be noted that the *gravity* criterion, which obtains the smallest growth in social cost, does not prove the best in terms of the increase in backlog. In particular, if the aim is a reduction in backlog the *diffusion* criterion proves the most effective, while the *gravity* criterion is the most effective in containing social cost. The *FIFO* criterion proves the worst in terms of both increase in backlog and social cost.

The case with a low productivity function for backlog reduction is a closer reflection of the real flow situation of the judge's workload. In the Tribunal of Catania, as in the rest of Italy, the entry flow of cases is higher than the exit flow and this, added to the waiting times in dealing with cases, is the main cause of congestion and of the lengthening of the time necessary to come to judgement.

In a perspective of reform policies, therefore, it is necessary to read the results of the simulation carefully before drawing conclusions regarding the choice of a priority criterion. If the main objective were a reduction in the social cost, then the choice of the *gravity* criterion would prove the most satisfactory. But if there is also a desire to reduce the backlog of cases pending, then the assessment is a different one and the *diffusion* criterion prevails. In the light of the results which emerged from the simulation, we may conclude that the *diffusion* criterion represents the best compromise between the two objectives. By comparing the two criteria, in fact, we may observe an increase in social cost of a mere +0.2% for the *diffusion* criterion, but a reduction in the backlog of cases pending of -0.8% compared to the *gravity*

criterion. In other words, the *diffusion* criterion limits the growth in social cost with better results on the overall backlog of cases pending.

4.2. *With a High-productivity Function*

Simulating the model with the high-productivity function $[v(t) = (\frac{1}{2}n_i) \cdot t]$, that is with a case examined every two days, the results are partly different from those obtained in the previous example. Obviously, there is an overall reduction in the backlog of cases pending ($\sum \lambda_i N_i < v_h$), for all the choice criteria applied. The results presented in Table 3, however, show that the trends of the backlog of cases pending for the different categories of crime are in some ways contradictory. In particular, we observe that the *gravity* criterion is able to reduce the backlog of fraud cases to zero and the backlog of handling cases by a large amount, but that there is an increase of 16,24% in the cases pending for harm to persons or property.

The *diffusion* criterion obtains the best results in terms of the overall reduction in backlog. Applying this criterion, it is possible to reduce to zero the procedures for harm, which represent the most voluminous backlog of cases and which have a higher growth rate than the other categories in Catania. The contradiction lies in the fact that we observe an overall reduction of -34% in spite of an increase in the backlog of procedures for fraud and handling.

Finally, the effects on the social cost confirm the results already obtained with the low-productivity function. There is a reduction in the social cost with all the criteria applied but with a clear prevalence of the *gravity* criterion, where the reduction in social cost is 67,3%, almost double that of the *FIFO* criterion (34,9%) and considerably higher than the *diffusion* criterion (12,6%).

	fraud	handling	harm	total	social cost
FIFO	-37,3	-37,8	-28,1	-31,7	-34,9
Gravity	-100	-88,4	+16,24	-30,7	-67,3
Diffusion	+6,7	+0,01	-62,5	-34	-12,6

Tab. 3 – *Percentage variations in the number of procedures and the social cost. Simulation with* ($\sum \lambda_i N_i < v_h$).

The case with high productivity function for reducing backlog represents the ideal situation, in which there are no problems of eliminating the accumulation of cases pending and the productivity of the judge is higher than the overall volume of cases to be examined. In this situation, all the choice criteria obtain a good performance in reducing the backlog of cases pending, with a slight preference for the *diffusion* criterion, while the *gravity* criterion is preferable for reducing social costs.

5. CONCLUSIONS

The principal aim of this paper is to offer some new guidelines for dealing with cases pending, in order to render the judicial service more rapid and especially attentive to those crimes considered to have a strong social impact. Some criteria of priority are suggested, as an alternative to the *FIFO* criterion, based on the order of arrival of cases. The individual *modus operandi* of a single judge in criminal law is also analyzed, thus confirming the theory that the application of one criterion of priority instead of another leads to a variation in results, in terms of a reduction in both the backlog of cases pending and social costs.

The effects of two criteria of priority were tested: *gravity* and *diffusion*. The main considerations that may be drawn from the simulations of criteria for dealing with backlog vary according to the objective pursued. In particular, if the main objective is to reduce social costs, and therefore, to reduce delays in bringing before the court those crimes with the highest social impact, the *gravity* criterion answers this requirement most effectively, albeit with the disadvantage of an increase in the overall volume of cases pending. On the other hand, the criterion of priority based on the diffusion of the crime proves more effective in reducing the overall backlog of cases pending albeit at a higher social cost.

We argue that although the results obtained are based on data obtained from a single section of the Tribunal of Catania, they may prove useful for a more generalised debate on problems of justice in Italy. An analysis of the work of a single magistrate has been carried out in the civil field (labour section) by other authors[16] who have underlined how the organizational decisions involved in dealing with procedures – "in sequence" rather than "in parallel" – appears to favour a reduction in the backlog of cases pending by accelerating the magistrate's work. The results of the present study are

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[16] D. COVIELLO, A. ICHINO, N. PERSICO, *Giudici in affanno*, cit.

closely connected with this, since it identifies the choice of the criterion of priority applied by the judge as one of the causes of the accumulation of cases pending and of the relative costs for society. It may be advisable to think twice before declaring that the problems of justice in Italy derive principally from the lack of resources or from the inadequate dimensions of the law-courts. Our simulations suggest that the individual decision of the judge regarding which criterion of priority to apply in treating cases has a strong impact on the reduction in cases pending and on the social cost deriving from delays in dealing with the more serious cases.