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DOI
10.1111/itor.12716

Publication date
2019

Document Version
Final published version

Published in
International Transactions in Operational Research

Citation (APA)
Blank, J. L. T., & van Heezik, A. A. S. (2019). Policy reforms and productivity change in the judiciary system: A cost function approach applied to time series of the Dutch judiciary system between 1980 and 2016. *International Transactions in Operational Research*, *27*(4), 2002-2020. https://doi.org/10.1111/itor.12716

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INTERNATIONAL TRANSACTIONS IN OPERATIONAL RESEARCH

Intl. Trans. in Op. Res. 00 (2019) 1–19
DOI: 10.1111/itor.12716

Policy reforms and productivity change in the judiciary system: a cost function approach applied to time series of the Dutch judiciary system between 1980 and 2016

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Received 24 September 2018; received in revised form 4 April 2019; accepted 12 August 2019

Abstract

The judiciary is constantly undergoing change in order to respond to a wide range of social developments that have brought the sector under increasing pressure. In order to deal with the constant call for enhancing budgets, different policy measures have been taken to downsize the appeal to the judiciary and to improve productivity. One of the central questions hereby is whether these measures have actually contributed to a more productive sector. This paper focuses on the development of productivity in the judiciary and how policy measures have affected productivity. In this empirical analysis, we apply a cost function model to time series data of the Dutch judiciary between 1980 and 2016. The results show a dramatic decline of productivity over the entire period (−50%), in spite of various policy measures. The year 2001 can be regarded as a turning point, as since then productivity has remained more or less stable. It seems that this is largely due to the establishment of the Council for the Judiciary and the associated increase in (financial and operational) autonomy for the judiciary. Another striking result is that technical change is biased toward using more personnel through time.

Keywords: judiciary; cost model; productivity change; time series; policy reforms

1. Introduction

Safety and justice are constantly undergoing change in an attempt to respond to a wide range of social developments that have brought these systems under increasing pressure. In the 1980s and 1990s, soaring crime rates played an especially important role in the Western world (Yezer, 2014). Individualization, the growth of economic activity and social safety, the increasing complexity of society, and other social trends have also contributed to the pressure on safety and justice. As a result,

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although these century crime rates are on the decline (Tonry, 2014), there is still a heavy burden on the system. In the Netherlands, for instance, this is particularly noticeable in the judiciary. Since 2000, there has been a considerable increase in the number of civil and administrative procedures. The Dutch judiciary therefore remains under pressure, even though there are fewer criminal cases to deal with. Relieving the pressure and limiting the costs involved is a difficult task for the government. One of the main characteristics of the judiciary is that it is a pure monopoly that does not face any form of competition. Government also has limited influence upon this sector because of the danger of being accused of undermining the independence and objectivity of the judiciary system, and therefore posing a threat to democratic institutions and the rule of law. It is to be expected that in this sector Baumol's cost disease has free rein.

In many countries, various policy measures have been taken to control costs and improve the productivity of the system. These vary from changes in funding, upscaling courts of law, organizational improvements, downsizing bureaucratic procedures and protocols, and introducing forms of new public management (yardstick competition, extending accountability). The question is whether all these measures have led to cost containment and/or increased productivity. In literature, we only find a limited number of papers that give an answer to this. Most of these articles, however, focus primarily on the determinants of efficiency and to a lesser extent on policy instruments. Moreover, they lack a solid methodology that integrates all different aspects of the judiciary.

The central topic of this paper is the relationship between policy and productivity in the judiciary system. In effect, the concept of productivity consists of the performance delivered (also referred to as "production") per Euro (especially tax money). Production is measured according to several product indicators (e.g., the number of concluded cases). In order to enhance insight into this topic, we examine policy and productivity developments between 1980 and 2016 within the judiciary system in the Netherlands. Therefore, the central question is twofold:

(1) What is the productivity growth between 1980 and 2016 in the judiciary system?
(2) Is there a relationship between major policy reforms and productivity growth in the system?

In order to answer these questions, we present a brief overview of the literature on policy and productivity in the judiciary system (Section 2). In Section 3, we discuss the Dutch judicial system and its most important reforms in the last four decades. Section 4 discusses the available data for a quantitative empirical analysis and shows some historical trends. Section 5 includes the mathematical specification of the model and the estimation technique applied. Section 6 discusses the outcomes of the analysis. The final section concludes the paper by drawing some conclusions from the link between policy reforms and productivity changes.

2. Literature review on productivity in the judiciary

2.1. Why do governments intervene in the judicial system?

There is a general consensus on the important role of the judiciary in society. A well-functioning judiciary that enjoys the trust of the citizens forms one of the most important conditions for effective social and economic interaction and thus for the welfare and prosperity of a society. In

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economic interactions, there are two conditions that are essential for the proper functioning of the market: security of property rights and enforcement of contracts. Security of property rights provides incentives to save and invest by protecting returns from these activities. Enforcement of contracts stimulate to enter economic transactions by discourage opportunistic behavior and reducing transaction costs. This contributes to economic growth in various ways. How large this effect is, depends on how well the judicial system works.

The performance of judicial systems comprises various dimensions such as judicial independence, accountability, and effectiveness. Another important dimension is judicial efficiency. Over the past decades, attention has been growing for this aspect of judicial performance. An important reason for this is the sharp rise in costs of the judicial system and the rapid increase in the length of judicial proceedings. These and other considerations have invited calls for judicial reforms. Often, the main purpose of these reforms is to improve the efficiency of the judicial system (Botero et al., 2003).

2.2. What policy instruments can the government use to enhance judicial efficiency?

In order to realize these efficiency-enhancing reforms, the government has a number of policy instruments at its disposal. These instruments can be subdivided into four categories, coinciding with four basic control options to influence the behavior of the actors involved: ownership, financing, market organization, and environment (Blank and van Heezik, 2017). This section presents a brief overview of the literature on the impact of measures relating to these four types of instruments on the productivity of the judiciary.

2.2.1. Ownership

Although a lot of research has been done over the years into the various ways of stimulating the productivity of the judiciary, there is little literature available on the effects of policy measures aimed at changes in the ownership structure, such as privatization. This is remarkable, as in recent decades there has been a strong increase in alternative dispute resolution in many countries. Many cases are now resolved outside the courthouse through mediation and arbitration, often performed by private actors or agencies (Hensler, 2003; Farrow, 2008). The effects of this development—the privatization of the dispute resolution—on the performance of the judiciary seem hardly to have been studied.

More research has been done into another development in the context of ownership. This concerns the introduction of the councils for the judiciary or judicial councils. In recent decades, these court administration authorities have been set up in many countries, giving the judiciary a more autonomous position in relation to the government (Ministry of Justice). However, these councils have different powers in different countries. Some of them are primarily concerned with the appointment of judges and disciplinary action, while other councils (also) play an active role in the financial (including budgeting) and administrative management of courts, as well as housing, education, and automation (Voermans and Albers, 2003). The latter is primarily intended to facilitate the effective and efficient management of the judiciary (Autheman and Elena, 2004). Whether this actually leads to more productivity, is unclear. The shift of a significant amount of power from the Justice Ministry to judicial councils may well affect judicial productivity, as Voigt and El-Bialy

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(2016) note. But they do not perceive a positive effect. Instead they find, based on data from the member states of the Council of Europe, that the existence of judicial councils is significantly correlated with lower judicial productivity. In the Netherlands, however, as it is stated in this article, there are indications that the Council for the Judiciary contributes positively to the efficiency of the judiciary.

2.2.2. Funding

When it comes to instruments relating to finances, the focus in literature is mainly on the size and composition of the judicial budget. Botero et al. (2003) distinguishes four schools of thought on judicial reform. One of them considers funding as the main problem of the judicial system. Most adherents of this view see the solution to judicial inefficiency as lying in more resources, making more money available for things such as better computer systems and more courts, judges, and clerks. However, on the basis of a literature review, Botero finds no convincing empirical evidence for this. A recent literature review (Gouveia et al., 2017) comes to the same conclusion. In general, the researchers note, studies assessing the impact of the overall budget of courts conclude that it has no effect on productivity. Voigt and El-Bialy (2016) even find a negative correlation between court budgets and production. A predominantly positive effect, however, is observed in several studies as a substantial part of the justice budget is allocated to information and communication technology (ICT). Courts that spend a larger share of the justice budget on ICT show both a shorter trial period and an increase in the number of cases handled per court (Gouveia et al., 2017).

2.2.3. Market structure

Many judicial reforms focus on measures that are intended to bring about changes in the market structure. This mainly concerns matters such as applying more productivity incentives and increasing the scale of operations. The literature review of Botero et al. (2003) indicates that creating the "right" incentives is probably the most promising way to stimulate judiciary productivity. This especially applies to incentive-oriented instruments that foster accountability, competition, and choice. However, recent research calls this observation into question. Voigt and El-Bialy (2016), for instance, find—based on data of the member states of the Council of Europe—that neither bonus payments nor benefits (such as housing, cars, drivers, etc.) or sanctions are robustly correlated with higher production. A better incentive appears to be the mandatory training courses for judges, which, according to the authors, do have a positive effect on efficiency (Gouveia et al., 2017).

As far as the scale of the judiciary system is concerned, it is often assumed that larger courts have a positive impact on judicial performance due to economies of scale and specialization. On the other hand, it can also have a negative effect because it may encourage evasion of duty. The larger the court, the easier it is for individual judges to hide behind their colleagues and shirk their responsibilities. The literature does not provide a very clear picture of the relationship between scale and efficiency in the judicial system. Voigt and El-Bialy (2016), for example, show that court size in the countries of the Council of Europe is virtually uncorrelated with the court's production. But Lorenzani and Lucidi (2014), based on data for European countries, find a negative relation between court size and both trial length and backlog ratio. By contrast, the evidence from single-country studies, focusing on court-level data, do find a positive relation between court size and efficiency.

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There is, however, also some country-level evidence that suggests no impact of court size on judicial performance (Gouveia et al., 2017).

The same ambiguity is observed with the effects of the degree of judicial specialization, which is closely related to court size. It is often assumed that specialization has a positive effect on efficiency, via economies of scale and uniformization of procedures. But there is also a downside. For example, specialized judges may be inclined to explore the cases more comprehensively, resulting in more time per case (Voigt and El-Bialy, 2016; Gouveia et al., 2017). Yet Palumbo et al. (2013) show that specialization is associated with shorter trial length.

2.2.4. Environment

All the above-mentioned instruments can be summarized as belonging to the supply side of the courts. Naturally, the demand for judicial services is an important additional factor that determines judicial productivity. The instruments that steer on the demand side form the largest part of the instruments that belong to the environment category. In the case of the judicial system, one should especially think of measures that influence access to the system. According to some, judicial systems are inefficient because of excessive and indiscriminate access. They suggest such solutions as greater procedural hurdles for lawsuits or increasing the costs of litigation. However, there is no convincing evidence that this will benefit productivity, according to Botero et al. (2003). They conclude that merely reducing access does not solve a chronic problem of court delay. They even point out that the relationship between access and efficiency is normally positive if an increase in access is accompanied by structural changes in the system. For example, by simplifying procedures and limiting the involvement of lawyers in parts of the litigation. Incidentally, it is also questionable whether measures to limit access work at all. A 2007 study by the U.K. Ministry of Justice that analyzed the impact of court fees on court demand, for instance, shows that demand is rather inelastic (Voigt, 2016).

The brief review given above makes clear that there is no panacea for government policies to enhance judicial productivity. For a comprehensive literature review, we refer to Botero et al. (2003), Gouveia et al. (2017), and Voigt (2016). However, a mixed picture also emerges from these more extensive literature searches, indicating that there are no unambiguous solutions to stimulate judicial productivity. Incidentally, it should be noted that the literature reviewed above is limited to a fairly small number of instruments. The government, and the judiciary itself, still have more instruments available for intervention. Some of these are discussed in the following.

3. Judicial reforms in the Netherlands

The Dutch judiciary system is constantly undergoing changes. Although most changes only consist of small adjustments, improvements, and nuances, some could be regarded as major reforms. The government uses such policy adjustments to respond to a wide range of social developments that have brought the judiciary under increasing pressure. Over time, these developments have led to a continuing call for higher budgets for the judiciary. However, especially at the beginning of the 1980s and during recent years, this call could not be met. At that time, the economy was in crisis, thereby requiring significant cutbacks in public spending, including expenditures on the judiciary.

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In the intervening period, policymakers have sought other ways to control the cost of the judiciary system. Solutions have been sought primarily in measures intended to improve both productivity and effectiveness of the sector. In particular, use is made of measures that intervene in ownership structure (i.e., increasing autonomy), funding (i.e., introduction of elements of performance financing), and market organization (i.e., upscaling and major reorganizations). In addition to these instruments, with which the supply side can be influenced, measures are taken to influence the demand side (Blank and van Heezik, 2017).

Initially, the government lays most emphasis on the use of these demand-side instruments. In the 1980s, various measures were taken to reduce the workload of the judiciary. One of the most important measures was the introduction of the Law Administrative Enforcement of Traffic Regulations (WAHV) in 1989. Through this law, commonly known as the Mulder law, all minor traffic violations, previously belonging to criminal law, were brought under administrative law and the handling was transferred to a special agency. This led in the 1990s to a workload shift from the judicial system (and police) to the direction of the Central Judicial Collection Agency (CJIB in Dutch), a part of the Ministry of Justice and Safety (Goldenbeld et al., 2000).

In the same period, preparations were made for reforms on the supply side. However, the implementation of the reforms only took place at the beginning of this century. An important measure in this respect was the establishment of the Council for the Judiciary in 2002. This created greater autonomy for the judiciary, particularly with regard to operational management and finances. As far as finances are concerned, policy has been firmly aimed at the incorporation of performance elements. Budgets have become increasingly linked to the delivery of output. In 2005, this form of performance pay was introduced for the judiciary (Langbroek, 2010; Council for the Judiciary, 2017).

Simultaneous to the introduction of the Council for the Judiciary, there was also a change in the (market) organization of the judiciary. This concerned a considerable scaling-up operation by means of merging different types of courts, namely the canton courts and district courts (Langbroek, 2010). A second major upscaling operation occurred in 2013, when the judicial map was reviewed and various judicial courts were merged again (van Dijk, 2014).

The judiciary does not lend itself easily to the introduction of market forces. The ultimate form of competition is yardstick competition. Fair comparison requires good data on a uniform system. Such a system (RechtspraaQ) has been available to the Dutch judiciary for some time (Dijkstra et al., 2017).

4. Data and historical trends

4.1. Data collection

The empirical analyses performed for this study are based on a set of time series variables of the Dutch judicial sector. The data are derived from a unique, interactive, and user-friendly publicly accessible database on public sector trends 1980–2016, also including figures on productivity change. This database *Trends in Public Sector* has been developed by IPSE Studies and contains information on various public sector services in the Netherlands, including education, healthcare, and infrastructure. Here variables on production, costs, and the use of resources for the Dutch judicial sector are used.

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Table 1
Data descriptives, 1979–2016

Variable	Mean	SD	Variance	Minimum	Maximum
Total costs	827.97	549.88	302,370.00	174.29	1639.30
Prosecutors' disposals	704.97	274.08	75,118.00	428.97	1402.00
Canton cases	746.99	223.21	49,825.00	491.00	1164.50
Court cases	574.76	148.04	21,916.00	350.24	791.53
Price personnel	52.87	20.07	402.88	30.76	88.42
Price material supplies	0.72	0.17	0.03	0.43	1.00
Price capital	0.09	0.01	0.00	0.06	0.11
Cost share personnel	0.67	0.06	0.00	0.59	0.78
Cost share material supplies	0.28	0.06	0.00	0.19	0.38
Cost share capital	0.05	0.03	0.00	0.02	0.11
Number of institutions	91.87	40.38	1630.20	28.00	132.00

The variables describe the Dutch judicial sector as a whole, so the differences in efficiency between the courts are obviously not taken into account. In addition to the courts, the Public Prosecution Service is also part of the Dutch judiciary. The data cover the period 1979–2016. This means that there are 38 observations. Note that we "lose" one observation in the analysis due to the use of a production growth variable (a lagged variable). Table 1 describes the data used in the analyses.

In the analysis of productivity and cost changes, three resources are distinguished: personnel, material supplies, and capital inputs. The costs of material supplies include the costs of outsourced activities. The costs of capital inputs are derived from the annual depreciation rate, interest rate, specific price index for capital investment, and capital supply.

Since the resource prices are not directly available from statistics, they are derived from other variables in the database. The price of personnel is computed as the personnel costs per full-time equivalent (FTEs). The price of material supplies is set at the consumer price index. Finally, the price of capital inputs is computed by dividing capital costs by the volume of capital inputs, calculated as explained below. The volume of personnel is given by the number of FTEs corrected for the number of working hours per year; the volume of material supplies is calculated by dividing the material costs by the price index of material supplies. The volume of capital inputs is derived from data on depreciation and investments in the judiciary, using the perpetual inventory method (Meinen et al., 1998). According to this method, the actual input of capital is equal to an aggregate of historical flow of investments, taking into account the depreciation of capital and the price of investment goods.

Production is measured by the number of decisions handed down by the public prosecution, the canton courts and the district courts. The canton courts (or subdistrict courts) are generally concerned with small claims, and cases of petty crime (referred to as canton cases). Figure 1 represents the development of each variable in the period 1980–2016 in index numbers with base year 1980. Within each case type, a further distinction between criminal, civil, and administrative case is possible. However, we cannot distinguish these outputs in the model due to the lack of degrees of freedom. Nevertheless, from accountancy reports we know that the costs of criminal and civil cases are more or less equal, while the costs of administrative cases are twice as high as civil and criminal cases. We have used these weights to aggregate the different case types within each group of canton and court cases.

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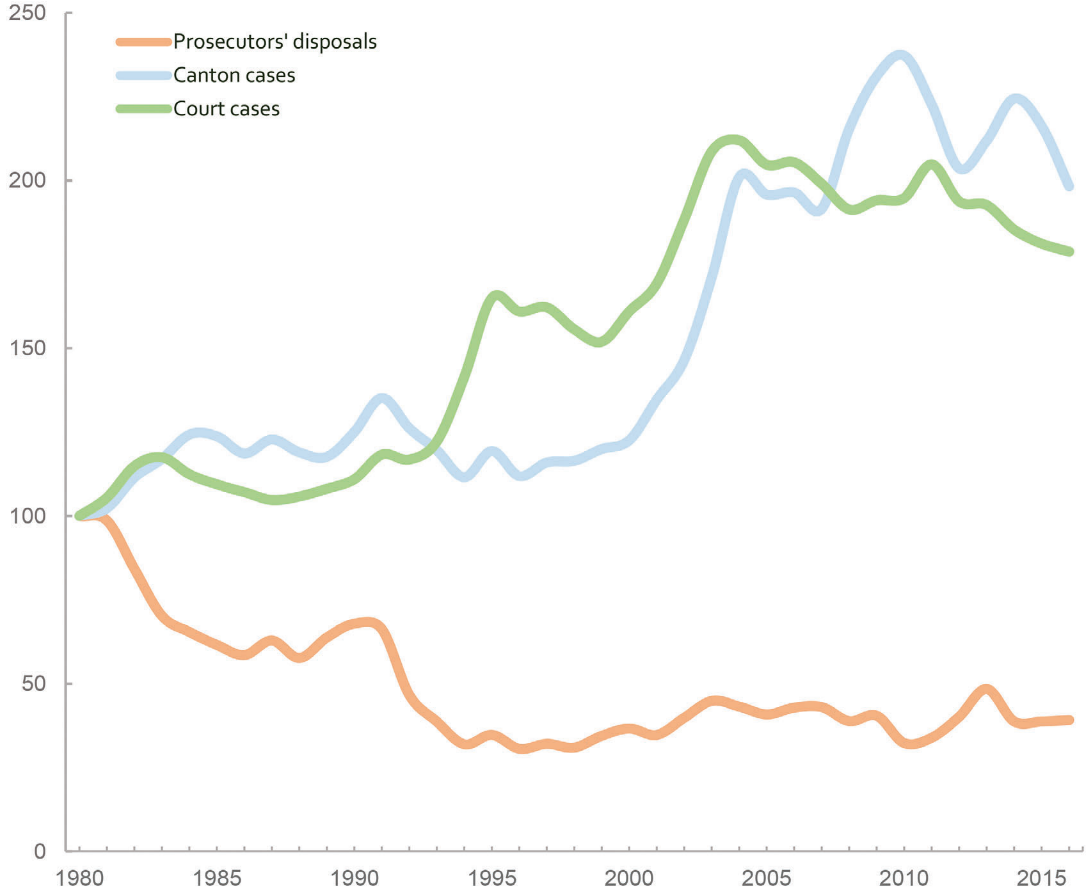

Fig. 1. Production of the judiciary, 1980–2016 (index numbers: 1980 = 100).

4.2. Development of production and inputs

Figure 1 shows a more than 50% decline in the number of prosecutor's disposals. This is mainly due to the aforementioned introduction of the WAHV. Although introduced in 1989, this law did not come into full force until 1992. A strong decline in disposals can be observed from this year onward. The other two services (canton and court of law cases) are almost doubled in the research period. The development of both services is rather erratic. In particular, the number of court cases rises strongly in the periods between 1992 and 1995, and between 1999 and 2003. In both periods, this is largely related to the increasing influx of asylum seekers who appeal against decisions by the Immigration and Naturalization Service. The number of canton cases rises between 2000 and 2004. This is caused by multiple factors, including an intensification of police action and law enforcement. General social developments, such as individualization and the growing complexity of society, also play a role in the increase of canton cases. This also applies to the growth of court cases.

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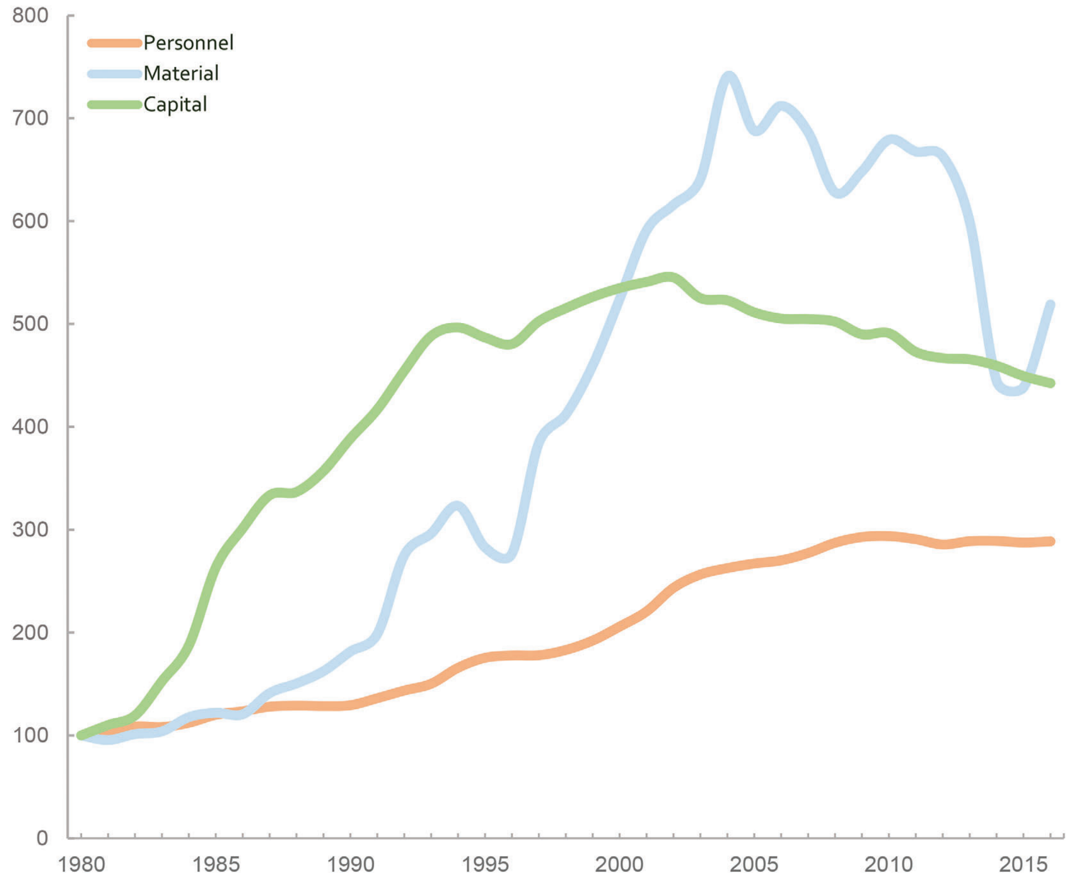

Fig. 2. Inputs of the judiciary, 1980–2016 (index numbers: 1980 = 100).

Figure 2 reflects the development of the inputs, all corrected for their corresponding input prices. Figure 2 shows an interesting development of the inputs. The first observation is that the development of each input beats the development of the production, indicating a severe decline of productivity. The "slowest" incline can be found with personnel (tripling) where the input of material supplies and capital show a multiplication between 4 and 5. It is also interesting to see how the composition of inputs has evolved. In the first period, it is obvious that capital and material supplies are becoming more important, whereas from 2002 the amount of both inputs decline and the input of personnel increases. So, there is no consistent pattern of how technology evolves during this period. Note that the input of capital is modest and for a large part consists of capital cost for housing. After the millennium change, courts of law do not own their own buildings anymore (due to legislation), but rent from a central government agency explaining the fall of capital after the year 2000. Rent for housing is accounted for in the material supplies explaining (partly) the rise of material inputs after 2000. The fall in material supplies after 2012 probably is a result of the budget cuts from the central government. The easiest way to reduce cost on a short notice is by reducing material costs.

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5. Specification and estimation

5.1. The cost function model

Productivity changes are derived from an estimated cost function. The productivity changes are measured at the national level, interpreting the judiciary system as the unit of observation. The cost function assumes a relationship between resources and services delivered. A cost function model allows for a multiple-resources multiple-services analysis that is suitable for studying complex sectors such as the judiciary. From the cost function, cost share equations can be derived that describe the demand for resources (Shephard, 1970).

A translog cost function (see Christensen et al., 1973) is used here, but in a hybrid form since most of the second-order terms are excluded. The translog function is a rather flexible form that allows for varying economies of scale, varying resource substitution, and varying technical change that comes from varying production levels, varying resource prices, and from different points in time. However, since the number of parameters would grow too large for our dataset that consists of 38 observations (note: there is one lagged variable), we have to restrict the flexibility to some extent using a hybrid form. Most of the second-order terms are excluded except for the interaction terms between a time trend and input prices. Since these terms (and corresponding parameters) reappear in the cost share equations as time trends, they can easily be estimated. Since no large variations, either in outputs or in input prices, exist, the effect of the exclusion of the second-order terms on the outcomes will be limited.

The cost equation also includes a first-order lag operator representing the dynamics of the system. Usually, a production change does not immediately lead to an equivalent change in cost. Initially, the present capacity will allow for an extension of production. Hiring staff and (especially) increasing capital inputs will lag behind. In this case, the estimated effects will therefore describe short-term reactions rather than long-term relationships. However, the production change may also cause a more sustainable change due to innovative behavior. This is known as Verdoorn's law (Verdoorn, 1949, 1980). In order to capture this effect, an additional term is added to the model reflecting production growth. In the case of the judiciary, a sudden increase in production may be interpreted as an increase in the occupancy rate of the judiciary capacity. The expected sign of this variable is negative.

The model also includes a measure for average scale, that is, total production divided by the number of institutions. Since scale effects can be negative, absent, or positive, no clear hypothesis can be formulated beforehand.

The time trend is derived from a set of splines. We have divided the time span in p (=4) different subperiods allowing for different time trends in different subperiods.

In general, econometric frameworks also include an error term reflecting specification errors and measurement errors. The possible specification errors also include some incidental changes of productivity (e.g., due to a change in legislation). Although in regular multivariate regression analysis, residuals are interpreted just as a stochastic component depending on measurement errors and misspecifications of the model, in this case they may reveal slightly more than a stochastic outcome. In particular, due to applying the autocorrelated regression method, the corrected residuals show a nonnormal pattern and reveal incidental shocks that may be interpreted as an incidental change in productivity. We therefore also present these uncorrected residuals.

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This leads to the following cost function model:
Equation (1): *Cost function*

$$\ln(C) = a_0 + \sum_{m}^{M} b_m \ln\left(y_m\right) + \sum_{n}^{N} c_n \ln\left(w_n\right) + b_0 \sum_{m}^{M} b_m \Delta \ln\left(y_m\right) + b_{eos} \sum_{m}^{M} b_m \left[\ln\left(y_m\right) - \ln\left(Ninst\right)\right] + \sum_{p}^{P} aa_p \left(t - T_{p-1}\right)\left(t > T_p\right) + \sum_{n}^{N} j_n \left(t - T_0\right) \ln\left(w_n\right) + u, \quad (1)$$

where y_m is the production service m ($m = 1, \ldots M$); $\Delta\ln(y_m)$ is the relative change in production service m ($m = 1, \ldots M$); w_n is the resource price n ($n = 1, \ldots, N$); t is time; T_p is the last year of period p; T_0 is the first year of analysis; and u is the error term. b_m, c_n, $b_{0,}$ b_{eos}, j_n, a_1, and aa_p are the parameters to be estimated.

The term ($t > T_p$) distinguishes the period of analysis into different time periods, in which a different speed of technical change may occur. They can be regarded as a set of splines, which allows for more erratic patterns than in the case of specifications with linear, square, or cubic terms. We have chosen to fix the cutoff points at 1989, 1998, and 2007.

The corresponding cost share equations can be derived using Shephard's lemma and are given by
Equation (2): *Cost share equations*

$$S_n = c_n + \sum_{n=1}^{N} j_n \left(t - T_0\right) + u_n \quad n = 1 \ldots N, \quad (2)$$

where S_n is the cost share of resource n.

For the parameters of resource prices, there is a homogeneity restriction (of degree 1). This means that a generic price increase leads to a proportional cost increase. In terms of parameter restrictions, this yields

$$\sum_{n=1}^{N} c_n = 1; \quad \sum_{n=1}^{N} j_n = 0.$$

The cost function must be nondecreasing in resource prices (a price increase cannot lead to a cost decrease). The cost function is nondecreasing if all predicted cost shares based on the estimated parameters are positive. Note that the usual requirements of concavity of the input prices are automatically fulfilled because of the fact that cross-terms of input prices are excluded from the equation.

Further, we impose *constant returns to scale*. This seems to be a reasonable assumption when working at a national level. Note that this is not a contradiction with the possibility of the

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existence of possible scale effects at the institution level, which will be reflected in the scale variable. Here, it means that an increase in (national) production leads to a proportional increase in costs:

$$\sum_{m=1}^{M} b_m = 1.$$

As aforementioned, productivity can be derived from the cost function. We define productivity as the ratio between an aggregated output indicator and an aggregated input indicator:

Equation (3): *Total factor productivity (TFP) measure*

$$TFP = \frac{f(Y)}{g(X)}. \tag{3}$$

For $f(Y)$, we take the geometric mean of the distinct outputs, whereas the weights depend on the shares of output values in a certain base year. Since output prices are lacking here, the output values are based on the costs that are involved in producing this output. Because of the functional form of the cost function, these output value shares coincide with the b_m parameters.

For the aggregated output indicator $g(X)$, we take actual costs deflated for price increases. The applied deflator here is also the geometric mean of input prices, where weights are based on cost shares in a certain base year. In this case, the cost shares coincide with the c_n parameters.

Equation (3) can therefore be rewritten as follows.

Equation (4): *TFP measure, linked with costs*

$$TFP = \frac{\prod_m y_m^{b_m}}{C/\prod_n w_n^{c_n}}. \tag{4}$$

With Equation (4) we have a one-to-one correspondence between the productivity measure and the cost function. By estimating the parameters of the cost function, we can also calculate the productivity measure. By rearranging the equation of the cost function, another interesting insight occurs. We may rewrite Equation (4) as follows.

Equation (5): *Decomposing TFP*

$$\begin{aligned} \ln(TFP) &= \sum_m b_m \ln(y_m) + \sum_n c_n \ln(w_n) - \ln(C) \\ &= -b_0 \sum_m^M b_m \Delta \ln(y_m) - b_{eos} \sum_m^M b_m \left[\ln(y_m) - \ln(Ninst)\right] \\ &\quad - \sum_p^P aa_p (t - T_{p-1})(t > T_p) - \sum_n^N j_n (t - T_0) \ln(w_n) - u. \end{aligned} \tag{5}$$

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From this expression, we can decompose the natural logarithm of TFP into different components reflecting the effects of the acceleration of production, the average scale of production, neutral technical change, biased technical change, and some residual.

Taking the differential (with respect to time) TFP change therefore can be decomposed as

Relative change in TFP
= relative production change + relative change input prices − relative cost change
= b_{eos} x relative change in scale + $b_0 x$ relative change production growth
+ neutral technical change + biased technical change + incidental cost change.

Since biased technical change is generally small, we aggregate the neutral and biased technical change and call it technical change.

5.2. *Estimation method*

The cost function model includes a large number of parameters, especially if all various resources and services are included. In particular, in a time series (as is the case here), estimating a large number of parameters leads to econometric problems arising from a number of causes.

First, time series usually have relatively few observations, leading to a limited number of degrees of freedom. Second, most time series are nonstationary, implying that using OLS would lead to spurious correlation. The strong correlation between observations would also lead to multicollinearity, yielding nonefficient estimators. The strong coherence between explanatory variables makes it impossible to attribute the variation in the endogenous variable to individual explanatory variables.

Econometrics offers several solutions to this problem. The simplest and most widely used method is to allow for autocorrelation by applying an autoregressive transformation to all the variables in the model. This means that the estimation deals with *changes* in variables rather than the *levels* themselves. This means that each variable f in the model is transformed as follows: $f - \rho f(-1)$. The parameter ρ is estimated as well. The trend and the corresponding correlation are then eliminated from the model. In some cases, it is even necessary to eliminate a second-order form of autocorrelation, which is the case here. Then the transformation is as follows: $f - \rho_1 f(-1)$- $\rho_2 f(-2)$. Multicollinearity can only be avoided by including additional information, such as fixing certain parameters beforehand, based on values found in earlier research, or by imposing theoretical restrictions.

Since the cost function model consists of a system of equations with parameter restrictions between equations, the method of *nonlinear* least squares is adopted, based on the Davidon–Fletcher–Powell algorithm.

6. Estimation results

Table 2 shows the estimates, standard errors, and t-values of the parameters. Table 2 shows that the model neatly represents the costs of the judiciary: a majority of parameters are statistically

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Table 2
Estimates cost function model with AR(2) correction

Variable name	Parameter	Estimate	SE	t-Value
Prosecutors' disposals	b_1	0.053	0.083	0.636
Canton cases	b_2	0.368***	0.125	2.934
Court cases	b_3	0.579***	0.140	4.126
Price personnel	c_1	0.606***	0.048	12.514
Price material supplies	c_2	0.276***	0.048	5.794
Price capital	c_3	0.118***	0.013	8.966
Average size court	b_{eos}	−0.028	0.034	−0.844
Production growth judiciary services	b_0	−0.326***	0.108	−3.009
1980–1989	aa_1	0.081***	0.024	3.357
1990–1998	aa_2	−0.046	0.028	−1.630
1999–2007	aa_3	−0.022	0.020	−1.099
2008–2016	aa_4	0.003	0.015	0.206
Trend share personnel	j_1	0.002	0.002	1.127
Trend share material supplies	j_2	0.001	0.002	0.391
Trend share capital	j_3	−0.003***	0.001	−6.073
Constant	a	−1.232***	0.238	−5.177
Autocorrelation	ρ_1	1.054***	0.086	12.201
Autocorrelation	ρ_2	−0.235***	0.081	−2.919

***Significant at 1% level.

significant at the 5% level. Due to log-linear specification, the b_m parameters can be interpreted as the (average) cost shares corresponding to the production of those specific outputs. This implies that on average 5.3% of costs corresponds to prosecutors' disposals, 36.8% to canton cases, and 57.9% to court cases. The standard errors are substantial, so there is a certain bandwidth. The hypothesis that the b_1 coefficient differs from 0 even cannot be rejected. We used a second-order autoregressive model. The model fit is obviously better than a first-order autoregressive model. The (absolute value) of the roots of the corresponding characteristic equation are both less than 1, indicating that the AR(2) process is stationary.

We also tested for the existence of (dis)economies of scale by including a variable that measures weighted output per institution. The test of constant returns to scale ($b_{eos} = 0$) could not be rejected. Obviously, the lack of data and the lack of variation in average scale make it very hard to identify possible economies of scale. From microeconomic analyses, we know that (dis)economies of scale exist in the judiciary (Gillespie, 1976; van Tulder and Spapens, 1990; Kittelsen and Førsund, 1992; Pedraja-Chaparro and Salinas-Jimenez, 1996).

The effect of the production growth variable, which indicates that production change itself leads to reduced costs (and thus increased productivity) due to the lagged responses to permanently growing services, is significantly negative (−0.326). This is in line with, for instance, Blank and Eggink (2014) who found a significant parameter of −0.45 for the production growth variable in Dutch hospital industry.

On average, the autonomous costs initially increase by 8.1% annually (not related to production or price changes) in the period 1980–1989. The following period (1990–1998) shows an annual autonomous increase in costs of 3.5% (=0.081 − 0.046), the next period 1999–2008 1.3% (=0.080

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$-$ 0.047 $-$ 0.022), and the final period 1.6% (=0.080 $-$ 0.047 $-$ 0.022 + 0.003). It is obvious that the autonomous increase in cost is rather persistent in the first half of the research period. Tests show that $aa_1 = 0$ and $aa_1 + aa_2 = 0$ are both rejected, implying that the autonomous trend between 1980 and 1999 is statistically significant. Tests further show that $aa_1 + aa_2 + aa_3 = 0$ and $aa_1 + aa_2 + aa_3 + aa_4 = 0$ cannot be rejected, implying that there is hardly any evidence that the autonomous cost growth is still negative. It appears that around 1999, there is some kind of turning point. We will come back to this later.

From the j_p, we can derive the nature of the technical change (Blank and Vogelaar, 2004). It shows that the relative share of personnel increases through time annually by 0.2% (not significantly at 5% level), whereas the role of capital diminishes by 0.3% (significantly at 5% level). The share of material supplies stays almost unchanged (+0.1%). This is a striking result, since it is to be expected that the share of personnel would have decreased, as in many other public services.

To check for the plausibility of the estimates, we also derived marginal costs for each distinct product. The marginal cost for a prosecutor's disposal equals €76. This might be considered as low, but bear in mind that the b_1-parameter has high standard error. The marginal cost for a canton case equals €357 and a (weighted) case for a court of law equals €730. Note that an administration case weighs twice as much as a civil or criminal case. These outcomes are plausible.

Figure 3 presents an overview of productivity growth for the judiciary since 1980. Productivity reflects the production delivered per euro, after controlling for resource prices. Product indicators for the judiciary include the number of cases closed, distinguishing between the public prosecutor's office, the cantons, and the court.

Further, we present the structural productivity trend and the incidental productivity change.

As indicated in Fig. 3, productivity in the judiciary has declined considerably. In 2016, productivity is only half the level of 1980. In particular, the productivity has lagged behind until around the turn of the century, after which it stabilized. It seems that this stabilization is to a large extent due to the reforms implemented around 2000. This applies in particular to the establishment of the Council for the Judiciary and the resulting increase in financial and operational autonomy for the judiciary. Probably, the implementation of incentives for higher production and economies of scale also contributed to reversing the downward trend. Figure 3 also shows that productivity growth has occurred twice in the preceding period. These growth periods are mainly due to production increases. In the early 1980s, there was a strong growth in the number of lawsuits, without additional resources being acquired for this. The recovery in 1995 can partly be explained by the increase in the number of immigration cases before the administrative court as a result of the influx of asylum seekers from the former Yugoslavia. Shortly thereafter, however, the negative development continues, while the production of justice is barely growing.

Figure 4 gives an impression of the underlying developments with respect to scale, occupancy rate, technical change, and incidental efficiency change. From Fig. 4, we note that technical change shows the most striking development. Between 1980 and 2016, productivity declines by about 70% due to technical change. This is striking since it is to be expected that in this sector ICT may have had a positive influence on productivity, just as in business services. The incidental efficiency change shows a slight mirror of technical change. At the beginning, the incidental component shows a strong upward movement, then fluctuates around 150. At the end of the period, the incidental component

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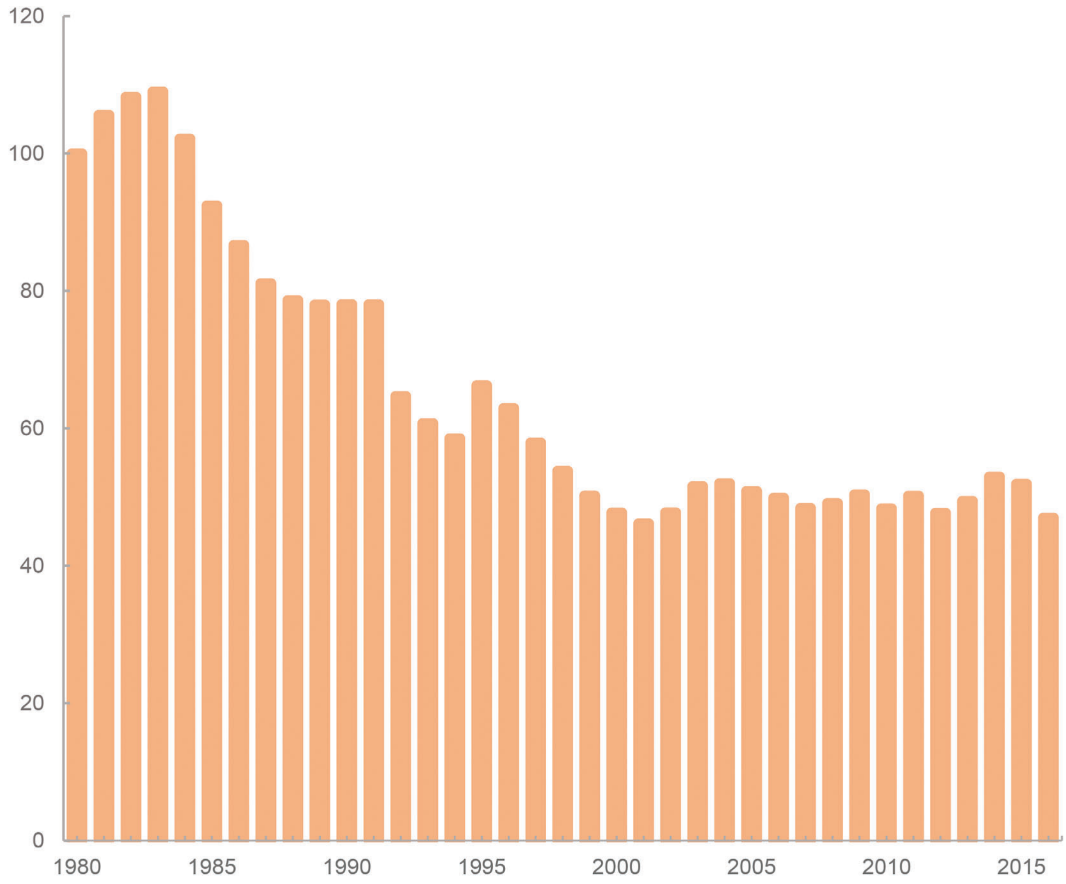

Fig. 3. Productivity growth in the judiciary, 1980–2016 (index numbers: 1980 = 100).

rises up to about 170. It may look as though the incidental efficiency change is compensating the downward technical change, but bear in mind that both developments are multiplicative. This implies that both developments lead to a composite development in 2016 with an index of 51 (=1.7 × 0.3 = 0.51).

Further sensitivity tests indeed show that there is some kind of communicating vessel between the trend and the residual component. Sensitivity tests include specifications with different distinct time periods or also including different constants per time period. However, TFP is hardly or not affected by each of these different specifications. Although the pattern of TFP is very robust, the substantial residual component indicates that there is some uncertainty about the outcomes. They may also reflect bad data, although we could not find any evidence for serious data flaws at the beginning or end of the research period.

From Fig. 4, we can also conclude that the effects of scale and production growth on productivity are negligible compared to technical change and the incidental component. Since scale only substantially changed in 2003 and 2013, there is a lack of variation in this variable, possibly leading to an underestimate of the true effect.

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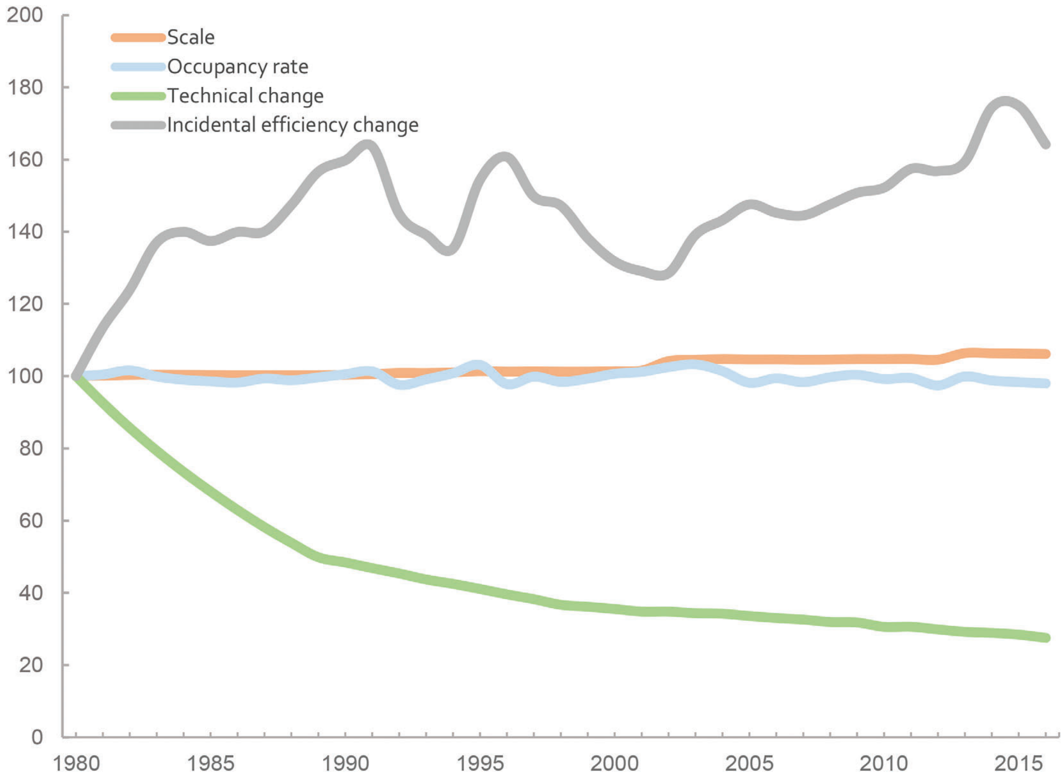

Fig. 4. Decomposition of productivity growth in the judiciary, 1980–2016 (index numbers: 1980 = 100).

7. Conclusions and policy implications

Over the past few decades, the Dutch safety and justice sector has faced a wide array of social changes, which have resulted in an increasing demand for services and therefore in an increasing service provision by the sector. Partly because of this development, the judicial sector has been confronted with several reforms. In the 1980s and early 1990s, these reforms were mainly focused on the demand side. An important measure in that context was the transfer of traffic violations to administrative law and having them dealt with by a special judicial collection agency. As a result, the workload of the judiciary decreased significantly.

However, it does not appear that this has had much effect on productivity. The downward trend that started after 1983 continues, albeit with fluctuations. This trend continues into 2001, the year in which productivity fell to a record low. Since then there has been a slight improvement, although productivity in the years thereafter remains around half that of 1980. Although productivity has not really improved in the period after 2001, the downward trend has clearly stopped. It seems that this is for a large part due to the reforms that were implemented during this period. The establishment of the Council for the Judiciary and the associated increase in (financial and operational) autonomy for the judiciary seem to have played a highly significant role. In addition, measures such as implementing incentives for higher production and economies of scale may have contributed to this development.

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Nevertheless, these reforms have not been able to stimulate productivity to an upward trend. To achieve this, other reforms are probably needed. In view of the hitherto negative influence of technical change, particular consideration could be given to increasing the use of technology. There seem to be plenty of opportunities for this in the ICT sphere. Exploring these possibilities is therefore recommended, as well as further research into the relationship between the judicial reforms and productivity outlined here. Microeconomic research offers good opportunities to gain a better understanding of this.

The focus of this paper is on the productivity issue. Even more important is the effectiveness of the judicial system. Although it seems that the reforms have had only a limited positive or even negative impact on the productivity of the system, they may have contributed to a more effective judicial system. A necessary condition for being effective is being efficient, but that is only a part of the story. The reforms may also have contributed to better social outcome (safety) due to a better coordination between other actors in the criminal justice chain such as the police. In the last decade, Dutch society has become much safer (less crime and accidents), indicating that are some positive side effects that have not been accounted for in our analysis.

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