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## MODEL AND TECHNOLOGY FOR PRIORITIZING THE IMPLEMENTATION OF END-TO-END BUSINESS PROCESS COMPONENTS OF THE GREEN ECONOMY

**Serhii Chalyi**

Kharkiv National University of Radio Electronics  
14 Nauka ave., Kharkiv, Ukraine

 <https://orcid.org/0000-0002-9982-9091>

**Ihor Levykin**

Kharkiv National University of Radio Electronics  
14 Nauka ave., Kharkiv, Ukraine, [ihor.levykin@nure.ua](mailto:ihor.levykin@nure.ua)

 <https://orcid.org/0000-0001-8086-237X>

**Igor Guryev**

University of Guanajuato  
Av. Universidad S/N, col. Yacatitas, Yuriria, Guanajuato, Mexico

 <https://orcid.org/0000-0001-6014-5912>

### Abstract

The problem of sustainable development of production is directly related to the three components of the "green economy" - economic, social, and environmental. Their harmonious combination makes it possible to obtain results that improve the social relations of both producers and consumers of goods and services. The implementation of the components of the "green economy" is carried out by various projects. The projects are carried out by irregular end-to-end business processes that compete for common resources in the process of their implementation. The impact on the components of the "green economy" is realized by the proposed model and technology. For this purpose, the software tool <ADVISOR DECISION-MAKER> was developed. The use of this tool by the decision-maker employee allows them to find the best solutions for process management. The solution is represented as priorities to access to shared resources by each process. This ensures their fulfillment within the deadlines established by the contracts. The level of innovations, economic indicators, production stability and competitive ability of products in a dynamically changing market is thereby improved. The results of such commercialization of scientific research have an impact on all components of the "green economy".

### Keywords

innovations, "green economy", economic indicators, social sphere end-to-end business process.

### Introduction

In contrast to the concept of sustainable development of production, in a "green economy" the development and stability of production is considered from the point of view of simultaneously achieving the social, economic, and environmental goals of a specific corporation or enterprise. This means that when creating a production development strategy focused on achieving certain economic indicators (profit, viability, etc.), the environmental and social components must be considered in complex [1]. The implementation of these components is carried out in the form of relevant projects. For each of such projects, a set of measures is drawn up. This is required to develop a model that would ensure the transition of production to a "green economy" and reorientation of its economic, environmental, and social components. The complex of such measures can be represented as a set of economic, environmental, social, innovative, irregular, end-to-end business processes (BP) competing for common resources during their implementation. The problem of managing such BP of corporations and enterprises is related to the fact that such processes do not use existing hierarchical approaches for the distribution of resources between their units [2]. This circumstance leads to competition for resources between BP, failure to meet deadlines, and consequently to a subsequent decrease in economic indicators, followed by risks and failure to achieve planned results in the economic and social spheres [3,4].

BP are represented by the appropriate sequence of actions. To manage BP, their detailed description is required for different environmental conditions, considering the access of each process to resources (competition for

resources between processes that run at the same time). Such a requirement makes it difficult to develop their models as it is necessary to consider the set of possible cross-functional sequences of actions that allow achieving the goals of these processes and the resources necessary to complete these actions. When determining the workflow, the necessary and sufficient conditions for such a description are identified. A necessary condition is its presentation in the form of admissible sequences of actions that ensure the achievement of a local goal regulated by the rules of operation of the enterprise, etc.

The conditions that are sufficient are those under which the process is running only if the appropriate resources are available at the time the action starts. The determination of the sequences of actions (workflow) is carried out both by means of the information-analytical system (IAS) and by the actions performed by the DM [5,6]. At the same time, the data necessary to support tasks is transmitted by the information system between the performers for the implementation of management functions.

Formally, such a description of the BP enables to define the overall workflow as a conjunction of possible trajectories for its implementation. The rationale for choosing such a description of BP is that it allows to represent both separate process and many parallel end-to-end processes as a set of trajectories. With this, it becomes possible to predict the use of resources only for a subset of the permissible current trajectories of each business process without considering all the trajectories, which increases the efficiency of forecasting the results. The advantage of this approach is improved coordination of the activities of various commercial entities within a single end-to-end process. This leads to the removal of barriers between divisions, helps to reduce the time and material costs which in turn improves the value of economic indicators of management objects. In addition, the employees are oriented towards the result. Consequently, the improvement of the social and psychological climate at the facility is ensured.

### **Methods**

The unsolved problem of process management by end-to-end BP is the complexity of the systemic presentation and understanding the incorrectness of their taking place [7]. Therefore, when forming possible sequences of actions for implementing end-to-end BP, the sequence that can only be performed with available resources should be selected. In fact, this sequence of actions displays workflow descriptions of the end-to-end business process [8,9,10]. In this regard, it is necessary to develop such a model of end-to-end BP that would make it possible to represent the state of the process at a formal level in the form of qualitative or quantitative parameters [11,12]. If the output parameters of BP do not correspond to commercial conditions, then it is necessary to find a solution that implements their transfer into the required state [13]. Such a decision is presented in the form of establishing priorities for access to the shared resources of competing BP that would ensure their implementation within the time frames established by the contracts [14,15].

At the same time, the composition of BP can change at some competitive points. This means that at some competitive point a business process may be included in the group of executed BP that do not compete with them for resources at previous points [16,17,18]. This problem is similar to the problem of the 3rd machines. However, when the number of competitive points is equal to 4 or more, it is extremely difficult to solve this problem with classical methods [19,20,21]. Therefore, we propose a model and technology to prioritize and initiate end-to-end BP at all competitive points, taking into account their normative and remaining time for performing actions of fixed IAS in the event log, both in automatic mode using the developed software <ADVISOR DECISION-MAKER> and with the involvement of the decision-maker. This tool provides support for the process of obtaining various variants of solutions for management of the end-to-end BP in the form of setting priorities for their initiation using the developed set of nested macros. The resulting solutions are provided by the decision-maker (DM) to find the best option for each order, in accordance with their current restrictions. The macros provide appropriate calculations and initiation of the platform, followed by saving the result in the database and the corresponding tables.

As shown by the practice of no more than 3 options, when finding the required solution, the DM can choose, from the group of end-to-end BP those which are the most important/key for an object, which must be fulfilled, as they directly affect its economic, environmental and social indicators. The need to obtain such a solution arises from situations related to the inclusion of a new project/order, failure or replacement of equipment, lack of materials, human factors and other types of incidents. In this connection, it is required to find appropriate

priorities for their implementation. The DM can also choose and add to the platform those competitive points that are needed for subsequent calculations.

The aim of the study is to develop a model and technology for finding solutions for the implementation of economic projects implemented by non-regular, end-to-end BP competing for common resources, while fulfilling the restrictions imposed on them.

### Results and discussion

The task of management for the end-to-end BP is to find the sequence of their execution at competitive points in order to minimize the waiting time of resources with restrictions on the execution time of each of these processes, as well as the waiting time for their access to resources. Process management means obtaining the required solution in the form of an ordered set of sequences of all actions of BP in all competitive points.

To develop a model for finding such a <Solution>, we introduced the following notations:

$Z(s) = (z_1, z_2, \dots, z_{c^z(s)})$  is the group of projects/orders at the  $s$ -th competitive point, where  $Z_i$  is the  $i$ -th order of the group  $Z(s)$  of orders at the  $s$ -th competitive point,  $C^z(s)$  is the number of orders in the group  $Z(s)$ . Fulfillment of the commercial order within the limits of its life cycle is carried out by the relevant BP:

$$Z_i = (B_1^i, B_2^i, \dots, B_l^i, \dots, B_{c_i^B}^i),$$

where  $B_l^i$  is  $l$ -th business process of the  $i$ -th order,  $C_i^B$  - the number of BP implementing the  $i$ -th order.

In doing so, each  $l$ -th business process is performed by a sequence of appropriate actions

$$B_l^i = (D_{l1}^i, \dots, D_{lj}^i, \dots, D_{lC_l^D}^i),$$

where  $D_{lj}^i$  is the  $j$ -th action of the  $l$ -th business process of the  $i$ -th order,  $C_l^D$  the number of actions in the  $l$ -th business process of the  $i$ -th order in the group  $Z(s)$ . At the same time, the implementation of BP  $B_l^i$  is associated with the following temporal parameters:

$T_i^{set}$  – is the execution time of the  $i$ -th order under the contract,

$t_i^{lefi}$  – is the remaining execution time of the  $i$ -th order

$t_{lj}^{i(h)}$  – is the normative (standard) execution time of the  $j$ -th action of the  $l$ -th business process for the relevant  $i$ -th order,

$t_{lj}^i(C_l^D)$  – is the execution time of the  $j$ -th action of the  $l$ -th business process for the  $i$ -th order.

The waiting time for each subsequent action is determined by the execution time of the previous action since the subsequent action can only be performed when the resource used by the previous action is released.

The resource restrictions associated with the waiting time of the corresponding business process are represented by the following expression:

$$\min(t_{lj}^{i(wt)}) / \forall B_l^i \quad t_l^i \leq t_l^{i \max}, \quad (1)$$

where  $t_{lj}^{i(wt)}$  – is the waiting time for resources to complete the  $j$ -th action of the  $l$ -th business process for the  $i$ -th order  $B_l^i$ ;

$t_l^i$  – is the time of execution for the  $l$ -th business process of the  $i$ -th order;

$t_l^i \leq t_l^{i \max}$  – is time limit for execution of the  $l$ -th business process.

Then the  $D_{lj}^i$  model for describing the actions of the  $j$ -th action for the  $l$ -th business process of the  $i$ -th order is represented as follows:

$$D_{lj}^i = (t_{lj}^h, t_{lj}^i(C_l^D), t_l^{i(wt)}, t_i^{lefi}) \quad (2)$$

The corresponding business process of the  $i$ -th order will be considered completed if the execution time of the  $j$ -th action is greater than or equal to zero

$$t_{lj}^i(C_l^D) \geq 0, \forall i \in C^Z(s), j \in C_l^D, l \in C_i^B. \quad (3)$$

The actual and remaining execution time will also be greater or equal to zero.

$$(T_i^{max} - T_i^{set}) \geq 0, \forall i \in C^Z(s), t_i^{lefi} \geq 0, \forall i \in C^Z(s). \quad (4)$$

Depending on the temporal parameters of the  $l$ -th business process at each  $s$ -th competitive point, it is necessary to find the optimal priority of their passage  $P_{ls}^i$ .

In accordance with the task, the model for finding the priorities of the passage of the  $l$ -th business process at the  $s$ -th competitive point can be represented as a tuple:

$$M = (T_i^{set}, t_i^{lefi}, t_{lj}^i(C_l^D), t_{lj}^h, P_{ls}^i). \quad (5)$$

The process of finding the optimal <Solution> is implemented by the technology being developed using this model while performing the following objective function:

$$\tau_{Z(s)} = \sum_{i=1}^{C^Z(s)} \sum_{l=1}^{C^B} (T_l^{iset} - T_l^{imax}) \rightarrow \min_{T_l^{iset}, T_l^{imax}} \quad (6)$$

To find the <Solutions> options (control actions) in the form of prioritizing access to the common resources of competing BP at the corresponding competitive points, which would ensure their implementation within the deadlines established by the contracts, the technology for their production is proposed. For example, when carrying out a group of economic projects, such common resources at competitive points may be human resources (a specialized team equipment installers performing installation work in several projects simultaneously). Doing so, we will take into account that the composition of the BPs can change at some competitive points. This means that a business process that does not compete with them for resources at previous points can be included in the group of executable BP. The process of finding the required <Solution> proposed is to be carried out in automatic mode using the software tool <ADVISOR DECISION-MAKER> and in a combined way with the inclusion of a decision-maker (DM) in such a process. To perform this, we use the following criteria: the remaining execution time of BP/orders and the time delay for their completion. The determination of the required <Solution> is carried out by several runs in automatic mode, and upon receipt of a negative result, the <Solution> DM is adjusted with the subsequent fixation of the 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup>, and 4<sup>th</sup> competitive points. The proposed technology is implemented in the following steps:

Stage 1. Generation of the initial data (the start and end time of the order execution, normative (standard) time  $t_{lj}^{i(h)}$  for the action of the business process and waiting time  $t_{lj}^{i(wt)}$  it takes for it to access the resources). The time parameters for each BPs are taken from the projects, and data on the resources for which they will compete (human resources, equipment, materials, etc.) and at which competitive points from the relevant regulatory documents.

Stage 2. Calculation of the duration of the  $j$ -th action for the  $l$ -th business process of the  $i$ -th order at competitive points in the form of the sum of two components:

$$t_{lj}^i = t_{ij}^{i(h)} + t_{lj}^{i(wt)}$$

The determination of the remaining execution time for each  $i$ -th order is carried out by subtracting from the execution time under the contract the execution time of the  $j$ -th action of the  $l$ -th business process of the  $i$ -th order:

$$t_i^{left} = T_i^{set} - t_{lj}^i.$$

Stage 3. Calculation of the values of the total remaining execution time of all orders according to the appropriate sequence of priorities:

$$T = \sum_{i=1}^N t_i^{left}$$

Stage 4. There should be set in automatic mode the priority of starting orders at the 1-st competitive point in the 1-st run, meeting the criterion of the maximum total remaining execution time  $T_l^{Smax}$  of the corresponding BPs.

By analogy, the values of its deviation from the largest  $T_l^{Smax}$  and current  $T_l^{Scur}$  in all priorities  $d_i$  are successively calculated at each subsequent competitive point. They determine to what extent the remaining time will change when initiation (launch) priorities change at subsequent competitive points:

$$d_i = T_l^{Smax} - T_l^{Scur}$$

Step 5. Correction by the DM of priorities sequences after the first run. Based on the miscalculation results at each competitive point obtained, the DM determines whether the conditions for the absence of negative values of the remaining business process execution time  $T_l^{Scur} > 0$  are met. If the conditions are met, then the obtained sequence of priorities is defined for initiating the BP at the corresponding competitive points. If these conditions are not met or the obtained sequence of priorities for some reason does not satisfy him, then the DM will continue to correct it.

Step 6. The determination of the initiation (start) priorities in the 2nd run is carried out using the criterion of the maximum delay in the execution of the BP. Its values are determined by the sum of the remaining time values  $t_i^{left}$  of the corresponding order in accordance with all options for establishing priorities at the last competitive point, based on the results obtained after the first run. In the presence of negative values, recalculation I automatically carried out. As a result, the order is determined for which the value of the delay time is the maximum. In this regard, this order must be initiated (launched) earlier. To accomplish this, the procedure "raising the priority of the order" is proposed. The procedure's essence is to determine such an order, the priority of which must be increased by one at the corresponding competitive points (to raise the order one level up), thereby assigning a new initiation (launch) priority. At the competitive points where this business process has the first priority of initiation (launch), their existing priority does not change. After the calculations performed by the platform, taking into account the results of the procedure "raising the priority of the order", the corresponding priority for each order is automatically and sequentially established at each competitive point. If after the calculations have been made there are negative values of the remaining time  $T_l^{Scur}$  for their execution, then this indicates a failure to fulfill the conditions of the orders and the absence of the <Solution> required.

Stage 7. Correction of the DM in the 3<sup>rd</sup> run of priorities sequences with fixing in the 2<sup>nd</sup> competitive points. Based on the data obtained, the DM determines which order should be moved up by priority according to the criterion of the maximum delay for each order. After that, the platform automatically recalculates the sequence of priorities in the remaining competitive points to determine the priority with the longest remaining execution time.

Step 8. Correction of the DM of priorities sequences after the third run. The DM considers all possible options obtained after changes in two competitive points, by fixing the first with subsequent changes in the other remaining points. All calculations for the remaining total execution time are carried out automatically based on the determination of possible priorities at competitive points and orders, the priority of which must be changed. According to the results of the data, the DM makes <Decisions> on choosing the best sequence

Stage 9. Initiation (Launch) of the fourth run, determines the possibility of finding the best result by fixing the 3<sup>rd</sup> competitive points, by the criterion of the value of the greater total remaining time than found after the run in the third stage. Each priority that was selected during the third run had certain  $d_i$  values. Sequentially established orders with their  $d_i$  values determined the total value  $d_s$ ,  $d_s = d_I + d_{II}$  according to the results of the 3<sup>rd</sup> run. Based on the obtained comparisons between the remaining runtime  $t_i^{lefi}$  and the total value of  $d_s$ , a search is made for such options of priorities at each stage of the runs, in which the total value of  $d_s$  will be less than the best result after the run in the third stage. Then the DM sorts out all the launch options that satisfy the given conditions with the search for such priorities wherein the total value of  $d_1$ ,  $d_2$ , and  $d_3$  will be less than  $d_s$  obtained after the 3<sup>rd</sup> run.

Stage 10. Finding the best option of the sequence of priorities for execution orders as to all competitive points by fixing the next fourth point is impossible due to the fact that the condition is not less than or equal to  $d_s$  obtained after fixing the 3<sup>rd</sup> points. When fixing the 4<sup>th</sup> point, this value will *only* increase, which indicates the receipt of the worst decisions.

Verification of the developed model and technology is carried out on the example of fulfillment of orders for manufacturing products by medium and large printing enterprises. Those are the enterprises with a discrete type of production, realizing both periodic and non-periodic (re-emerging) new orders at the same time. The group under consideration consists of 3 projects / orders competing for common resources. The first order is a book, the second a brochure and the third is a magazine. During this testing, the software developed by <ADVISOR DECISION-MAKER> was used. When developing the <ADVISOR DECISION-MAKER> tool, Visual Basic language was used. During the development process, 265 macros were written. Using this tool, enables to get the optimal sequence of execution of orders at the enterprise. The essential problem is that orders competing for resources at corresponding points have different parameters for their execution. Therefore, all possible priorities for launching orders at each competitive point are determined in order to find the optimal priority for their implementation. During this testing, the software <ADVISOR DECISION-MAKER> was used.

In this regard, we formulated the problem to be solved in the form of finding the optimal sequence of possible priorities for launching orders at each competitive point limiting their execution time according to the contracts. In each competitive point, several kinds of orders can be considered, namely, the orders competing for resources at previous points, orders that have completed their own processes and new key orders that have just been sent to production. The key BP are the ones of the highest priority for the company according to their financial indicators, and customers constancy. Then the start and finish time of each order is recorded at each competitive point, data on the start and end time of the order is recorded, the standard time for the execution of the business process and the time it takes for it to access resources are entered from the database. The criterion for determining the priority of launching each order at the 1<sup>st</sup> competitive point is the longest remaining time for all orders of all priorities. To determine this, we will form a table of values of the standard execution time of each action for all priorities according to the technological maps in Table 1.

Table 1. Values of the standard time for the execution of BP for all launch priorities at the first competitive point.

Source: Author's research

Orders	Priorities					
	123	132	231	213	312	321
Order1	4	4	8	8	10	10
Order2	8	10	10	4	4	8
Order3	10	8	4	10	8	4

The calculation of the waiting time of the BP at each competitive point is carried out as follows. Since the 1st BP has a standard runtime shorter than the others, its waiting time is 0.

The execution time of the action of BP  $t_{ij}^i(C_l^D)$  is automatically calculated by adding  $t_{ij}^{i(wt)}$  and  $t_{ij}^{i(h)}$ . For example, the 1<sup>st</sup> BP has a waiting time of 0, therefore its execution time is 4, the 2<sup>nd</sup> BP has a waiting time of 4 (which is the execution time of the 1<sup>st</sup> BP), the standard time is 8 and, accordingly, its execution time will be 12. The 3<sup>rd</sup> BP waiting time is found by adding the standard execution time of the 1<sup>st</sup> and 2<sup>nd</sup> BP (4 + 8) and its standard execution time which is 10. As a result, its execution time is 22. In addition, the total execution time was determined according to the relevant priorities for starting the BP. For example, the longest total execution time is at the priority 321 and equals 50 which is the worst-case scenario, while the priority 123 is the best because it has the shortest total execution time. Calculations of the BP execution time for all possible priorities and their total execution time at the 1<sup>st</sup> competitive point are presented in Table 2.

Table 2. Values of the execution time of BP in the 1st competitive point. *Source: Author's research*

Orders	Priorities					
	123	132	231	213	312	321
Order1	4	4	8	8	10	10
Order2	12	14	18	12	14	18
Order3	22	22	22	22	22	22
Total	38	40	48	42	46	50

The calculation of the remaining execution time  $t_i^{lefi}$  for each BP in all priorities is determined by subtracting the regulatory runtime  $t_{ij}^{i(h)}$  (Table 2) from the execution time of each order under the contract  $T_i^{set}$ . For example, for the first priority, when the order execution time is 120,110,100, the remaining execution time for each BP is 116.98.78. In the same manner these values are calculated for the remaining priorities. The values of the total remaining execution time of the 3 orders are also calculated in accordance with a certain priority of their passage as shown in Table 3.

Table 3. The remaining BP execution time for all priorities at the 1st competitive point. *Source: Author's research*

Execution number	Priorities					
	123	132	231	213	312	321
№ 1	116	116	102	102	90	90
№ 2	98	86	82	108	106	92
№ 3	78	88	98	78	88	98
Total	292	290	282	288	284	280
d <sub>1</sub>	0	2	10	4	8	12

The priority 123 of the BPs launch at the 1<sup>st</sup> control point with a maximum total remaining time of 292 is the most favorable/acceptable since it has the shortest execution time for all orders. To determine how launch priorities will change at subsequent competitive points, we introduce the d<sub>i</sub> parameter, which determines deviations from the highest value of 292 corresponding to the current value for all priorities. Accordingly, for 292, the value of d<sub>1</sub> is 0, and for each subsequent priority they are determined by the difference between the highest and the current value (Table 3). The parameter d<sub>i</sub> determines the change in the remaining time when adjusting the initiation (launch) priorities at subsequent competitive points. At the 1<sup>st</sup> run, according to the criterion of the maximum total remaining execution time of the corresponding BP, the priorities for launching of all BPs are set at the 1<sup>st</sup> competitive point. Also in the 1<sup>st</sup> competitive point, the best priority is selected to have the value of d<sub>2</sub> equal to 0. According to the d<sub>2</sub> value the remaining execution time of each order is determined. In the same manner, the d<sub>i</sub> values are sequentially computed at each subsequent competitive point with the choice of the next best priority from the d<sub>1</sub> passing values of the corresponding point. Thus, using the values of the maximum remaining total execution time of all orders, the optimal priority of passing BP at each competitive point is determined in Table 4.

Table 4. The remaining BP execution time for all priorities at the 7th competitive point. Source: Author's research

Execution number	Priorities					
	123	132	231	213	312	321
№ 1	-10	-10	14	14	42	42
№ 2	2	30	38	-14	-19	5
№ 3	26	-7	-23	26	-7	-23
Total	18	13	29	26	16	24

Table 4 presents the total data on the remaining execution time of 3 BPs after passing the last (i.e., 7<sup>th</sup>) competitive point, determined by the sum of its values for each BP in the respective priorities.

For example, for the 1<sup>st</sup> BP, according to the corresponding priorities, the values of the remaining time are equal to -10, -10, -23, -14, -19, -23 (-99 in total). We assume that the successful completion of all 3 orders is the condition for the absence of negative values in a certain priority of BP launch. As can be seen from Table 4, this condition is not fulfilled, therefore, the best result where the priority at the 7<sup>th</sup> competitive point contains the smallest sum of negative values is taken as acceptable. Such a priority is 123 with a value of -10 for the 1<sup>st</sup>, 2 for the 2<sup>nd</sup> order and 26 for the 3<sup>rd</sup> order. In total this gives the remaining time equal to 18. Nevertheless, in the case of the 1<sup>st</sup> order, the value is negative, which means the absence of the required <Solution>.

However, this criterion also failed to obtain the required <Solution>, since in all priorities there are one or more negative values. Therefore, the adjustment of sequences of priorities after the first run is carried out by the DM employee of the planning department. Based on the results of miscalculations at each competitive point, the employee determines whether the condition  $t_i^{efi} > 0$  is satisfied. If this condition is not fulfilled or the obtained sequence of priorities for some reason does not satisfy him, then the second run is carried out.

To determine the launch priorities in the second run, the criterion of the maximum delay in the execution of orders in all priorities is used. The delay time is determined by the sum of the remaining time values of the corresponding order in accordance with all options for setting priorities at the 7<sup>th</sup> competitive point, based on the results obtained after the first run. To exclude the occurrence of negative values, the platform automatically calculates the delay time, as a result of which the order is determined; the values of the delay criterion there of are minimal. The found order is initiated (launched) earlier using the "rise" procedure, raising the order 1 level up. As a result of calculations, the corresponding priority for each order is automatically and sequentially defined at each competitive point. If negative values are obtained, then this shows the absence of priorities satisfying the conditions for fulfilling orders after the 2<sup>nd</sup> run.

Similarly, the search for the desired result in the form of adjusting the sequence of priorities for launch orders after the second run is carried out by the DM. Using the values of the total remaining execution time  $T_l^{Smax}$ , the DM can change options of sequences of priorities with subsequent storage of them in the corresponding tables for the obtained results to make a detailed analysis of the obtained data. If the required result is not obtained, the DM continues the search for possible options for determining priorities by fixing the 2<sup>nd</sup> competitive points on the 3<sup>rd</sup> run. To do this, in two competitive points, the corresponding priority is fixed with the definition of the order, which must be moved up, based on the criterion of maximum delay. The data on the remaining time for all orders of printing products at each fixed point is presented in the column "Remaining time", fig 1. If the (-) sign appears, then there are no options at such a fixed point that satisfy the order fulfillment condition.

All tab.	Drop	Clean	№	Point	d	Priority	Time left	Set	Prior. Ch.	Order 3	Order 2	Choice	Fixing point	Time left
Tab 1_1		Com.p1.1	1	Point 1	10	231	-					P 1_1		0
	Tab 1_2		2	Point 1	4	213	-						P 1_2	0
Tab 2_1		Com.p2.1	3	Point 2	3	231	-			3	231	P 2_1		14
	Tab 2_2		4	Point 2	8	213	18	+		3	213		P 2_2	18
Tab 3_1		Com.p3.	5	Point 3	8	123	18	+		3	123	P 3_1		20
	Tab 3_2		6	Point 3	0	321	20	+	132	3	321		P 3_2	20
Tab 4_1		Com.p4.1	7	Point 4	3	231	-			3	231	P 4_1		15
	Tab 4_2		8	Point 4	10	213	16	+		3	213		P 4_2	16
Tab 5_1		Com.p5.1	9	Point 5	2	231	-			3	231	P 5_1		12
	Tab 5_2		10	Point 5	10	213	-			3	213		P 5_2	0
Tab 6_1		Com.p6.1	11	Point 6	11	123	-			3	123	P 6_1		11
	Tab 6_2		12	Point 6	3	321	-			3	321		P 6_2	18
							20							

Fig. 1. Data on the total remaining time. Source: Author's research

Thus, after the 3<sup>rd</sup> run is completed, the best option that satisfies the conditions for fulfilling all orders, with the greatest remaining time of 20, is a sequence of priorities for initiating (starting) BP at the corresponding control points. To determine the possibility of a better result, the DM can start the 4<sup>th</sup> run by fixing the 3<sup>rd</sup> competitive points according to the total value  $d_s$  obtained from the results of the 3<sup>rd</sup> run. By comparing between  $t_i^{left}$  and the total value of  $d_s$ , the search for such variants of priorities at each stage of the run is found, by doing so, the total value of  $d_s$  should be less than the best result after the run in the third stage. These results are priorities with 20 and  $d_s$  equals to 6. Therefore, a search is then made for sequences of initiation (launch) priorities for such a check, in which  $d_s$  should be less than 6. Since all options of fixing the 2<sup>nd</sup> points have been tested, a search is performed of fixing the 3<sup>rd</sup> competitive points.

The DMs sort out all the launch options that satisfy the given conditions. As practice shows, such options usually find place in the range from 3 to 5, which takes no more than 1-2 minutes. The decision maker, using the  $d_s$  value, manually searches for such priorities, in which the total value of  $d_1$ ,  $d_2$ , and  $d_3$  will be less than the value of  $d_s$  obtained after the 3<sup>rd</sup> run. To find the best sequence, first a competitive point is fixed with a minimum  $d_i$  value, and then the second and third competitive points with the same values are sequentially fixed. Their values are then summarized and compared with the  $d_s$  value obtained in step 3. In this case, the condition must be fulfilled under which  $d_s$  should always be greater. If a variant of determining the sequence of launch priorities that meets the conditions for fulfilling orders is found, then the value of the remaining total time of order fulfillment is compared with the same value obtained in the 3<sup>rd</sup> run. In this case, after 4 runs with fixing of the 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup>, and 4<sup>th</sup> competitive points (CP), the sequences are selected in which the remaining time is longer. The resulting data on the remaining execution time for all runs is presented in table 5.

Table 5. The resulting data on the passage of orders for all runs. *Source: Author's research*

Kod BP	Kod processes	Runs	Name BP	Time general	Time end	Time left
<b>Total: book</b>		Run 1	book	120	130	<b>-10</b>
<b>Total: brochure</b>		Run 1	brochure	110	108	<b>2</b>
<b>Total: magazine</b>		Run 1	magazine	100	74	<b>26</b>
<b>Total: book</b>		Run 2	book	120	123	<b>-3</b>
<b>Total: brochure</b>		Run 2	brochure	110	101	<b>9</b>
<b>Total: magazine</b>		Run 2	magazine	100	98	<b>2</b>
<b>Total: book</b>		Run 3	book	120	120	<b>0</b>
<b>Total: brochure</b>		Run 3	brochure	110	106	<b>4</b>
<b>Total: magazine</b>		Run 3	magazine	100	84	<b>16</b>
<b>Total: book</b>		Run 4	book	120	118	<b>2</b>
<b>Total: brochure</b>		Run 4	brochure	110	109	<b>1</b>
<b>Total: magazine</b>		Run 4	magazine	100	84	<b>16</b>

Analysis of the data in Table 5 allows us to observe the dynamics of improving the options for the resulting solutions. On the 3<sup>rd</sup> and 4<sup>th</sup> runs there are no negative values. This means that all orders will be completed on time.

Thus, during the four runs, the <Solution> has been obtained in the form of the best sequence of priorities satisfying the conditions for fulfillment of all orders (Z), presented in Table 6.

Table 6. The resulting sequence of initiation of BP for all 4 runs. *Source: Author's research*

Runs	Competitive points (CP)							Remaining time
	1 CP	2 CP	3 CP	4 CP	5 CP	6 CP	7 CP	
Run 1	123	312	312	231	321	312	213	Z1(-10)
Run 2	123	321	321	213	321	312	123	Z1(-3)
Run 3	123	321	132	321	321	312	213	20
Run 4	123	312	312	231	321	312	213	19

The table shows that the best result was obtained at run 3, according to it, all conditions of the orders were met (there were no negative values), and the total remaining time for all orders was 20 (for the first order 4 hours, for the second 0 hours and for the third 16 hours). During the first and second runs, the conditions were not met, since the delay in the execution time for the first order Z1 was 10 hours and for the second run is equal to 3 hours respectively.

The results of the practical implementation of the task are presented in Table 7. This table displays data on the life cycle of 3 orders (books, brochures, and magazines). For each order, all the necessary data is presented to determine the remaining execution time. The practical implementation of finding the best result is presented and in fact, this data reflects the content of the options for the Decision on the passage of these orders at all competitive points. The storage of these <Solution> in the database of the information system ensures their application in the management of similar orders.

Table 7. Data on the passage of orders at the best option. *Source: Author's research*

Kod BP	Kod processes	Runs	Priority	Name BP	Time process	Time general	Time waiting	Time end	Time left
1	1	Run 3	1	book	4	120	0	4	116
1	2	Run 3	3	book	10	120	13	23	93
1	3	Run 3	1	book	10	120	0	10	83
1	5	Run 3	3	book	14	120	17	31	52
1	6	Run 3	3	book	12	120	10	22	30
1	7	Run 3	2	book	9	120	5	14	16
1	8	Run 3	2	book	12	120	4	16	0
<b>Total: book</b>								120	<b>0</b>
2	1	Run 3	2	brochure	8	110	4	12	98
2	2	Run 3	2	brochure	8	110	5	13	85
2	3	Run 3	3	brochure	8	110	16	24	61
2	5	Run 3	2	brochure	10	110	7	17	44
2	6	Run 3	2	brochure	6	110	4	10	34
2	7	Run 3	3	brochure	12	110	14	26	8
2	8	Run 3	1	brochure	4	110	0	4	4
<b>Total: brochure</b>								106	<b>4</b>
5	1	Run 3	3	magazine	10	100	12	22	78
5	2	Run 3	1	magazine	5	100	0	5	73
5	3	Run 3	2	magazine	6	100	10	16	57
5	5	Run 3	1	magazine	7	100	0	7	50
5	6	Run 3	1	magazine	4	100	0	4	46
5	7	Run 3	1	magazine	5	100	0	5	41
5	8	Run 3	3	magazine	9	100	16	25	16
<b>Total: magazine</b>								84	<b>16</b>

This is the best sequence of priorities for initiating (starting) BP at the corresponding control points with the remaining value of time equal to 20 as presented in Table 8.

Table 8. The resulting data on the priorities sequences of passing orders at the best option. *Source: Author's research*

Orders	Priorities at competitive points						
	1 CP 123	2 CP 321	3 CP 132	4 CP 321	5 CP 321	6 CP 312	7 CP 213
Order1	1	3	1	3	3	2	2
Order2	2	2	3	2	2	3	1
Order3	3	1	2	1	1	1	3

Figure 2 shows all the possible and optimal sequences for all orders to pass through competitive points after three runs according to Table 2. For the 1<sup>st</sup> order, the optimal sequence is shown by a bold continuous line, for the 2<sup>nd</sup> order, the sequence is shown by a bold dotted line, while the 3<sup>rd</sup> ordering sequence is highlighted by a line consisting of dots.

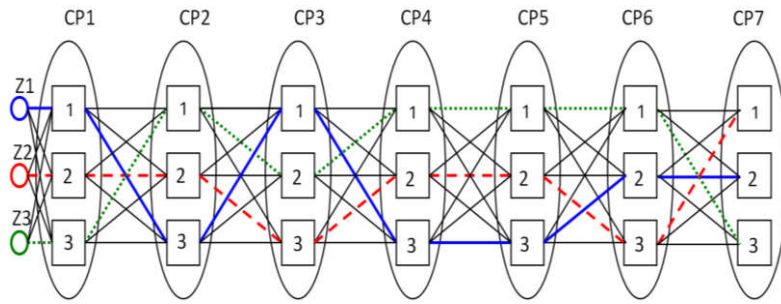


Fig. 2. The resulting traces of sequences of priorities passing by the competitive points of orders.  
 Source: Author’s research

Similar to the example described above, to consider the effectiveness of the developed platform, we will show its work on the example of 10 orders. The portfolio of orders of this group was formed as they arrived over a certain period of time. A prerequisite for all orders is their execution within the deadlines established by the contracts. When forming the order of execution of each order, it is necessary to take into account the time parameters of the remaining orders of the group. In addition, the remaining time for them should be maximum. Table 9 shows the results of calculations using Standard management tools.

Table 9. Execution time data obtained using standard management tools. Source: Author’s research

Standard management tools	Orders									
	№ 1	№ 2	№ 3	№ 4	№ 5	№ 6	№ 7	№ 8	№ 9	№ 10
Contract time	120	110	100	70	80	75	90	96	95	80
Actual time	134	96	74	60	88	65	85	109	89	71
Time left	-14	14	26	10	-8	10	5	-13	6	9

Based on the results presented in this table, it can be seen that some orders have negative values of the remaining time. The presence of negative time indicates a delay in the completed order, which indicates a failure to fulfill the order on time. This means that the previously assigned requirements were not fulfilled when executing the order portfolio. Failure to fulfill the order portfolio leads to penalties, loss of profits, rupture of contracts, a fall in the image of the enterprise, etc.

Table 10. Data on execution time obtained using Tool <ADVISOR DECISION-MAKER>. Source: Author’s research

Tool <ADVISOR DECISION -MAKER>	Orders									
	№ 1	№ 2	№ 3	№ 4	№ 5	№ 6	№ 7	№ 8	№ 9	№ 10
Contract time	120	110	100	70	80	75	90	96	95	80
Actual time	120	106	84	60	72	70	75	94	90	76
Time left	0	4	16	10	8	5	15	2	5	4

For clarity, according to the data of Table 9 and Table 10, a histogram is developed, which is shown in Figure 3. It allows the planner to quickly evaluate the progress of each order.

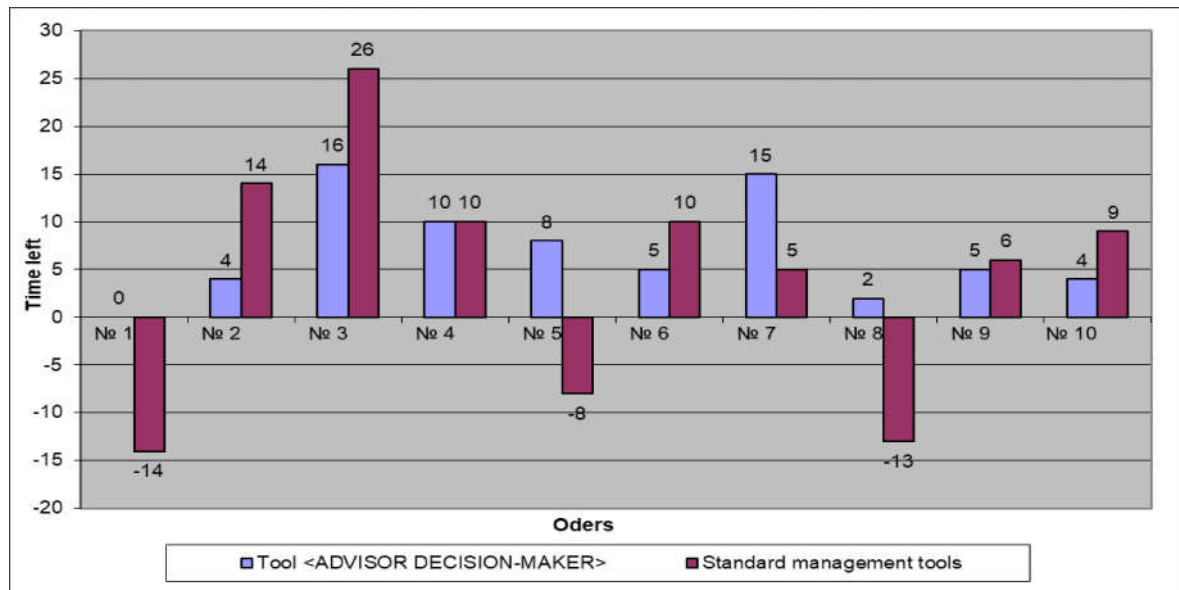


Fig. 3. Time remaining data obtained using tool <ADVISOR DECISION-MAKER>. Source: Author's research

Based on the results obtained in accordance with the established conditions the following conclusions can be made about the effectiveness of using tool <ADVISOR DECISION-MAKER>. Firstly, the entire group of orders is completed on time. Secondly, this group of orders has a maximum reserve of the remaining time, which can be used by the scheduler to expand the portfolio of orders.

Thus, the task was solved for the case of printing orders competing for common resources and having different parameters for their implementation. The DM using the software tool <ADVISOR DECISION-MAKER> has found the <Solution> in the form of optimal sequences of passage of competitive points by all orders. The implementation of such a Decision ensures the fulfillment of all orders within the deadlines established by the contracts.

The result of the work is a model and technology to find priorities for the implementation of end-to-end BP with restrictions on the available shared resources, taking into account causal relationships between the actions of the business process and the possibility of obtaining such dependencies.

They enable the DM to find the sequence of implementation of end-to-end BP, not only at the initial stage of their formation but also to change their set by including a new process at various stages of the life cycle of project implementation. Finding the required <Solution> is carried out both in automatic and in combined mode with the participation of the DM [18].

The main difference of the proposed model and technology is the formation of business process initiation (launch) sequences, which is carried out with their sequential fixing at the 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup>, and 4<sup>th</sup> competitive points until the desired result is obtained.

Their advantage is the implementation of the process of finding such sequences using the criteria of the remaining time and delay time for each business process, which satisfy the DM imposed restrictions on all orders. As a drawback, it should be noted the requirement of preliminary familiarization of the DM with the features and capabilities of the software tool <ADVISOR DECISION-MAKER>. It is used to implement a combined mode of finding the required sequence of access for a set of end-to-end BP to resources common to them, with their obligatory implementation within the deadlines established by the contracts. The model and technology can be applied to various subject areas in which the tasks of planning and operational management of end-to-end BP of a product release or the provision of relevant services to various users are realized and it determines the need for their further development.

### Impact

The impact on the economic and social components of the "green economy" by the proposed model and technology is considered in direct proportion to the improvement of management activities of the staff

of a printing company or corporation. Effective management of such complex organizational objects depends first of all on taking into account many interrelated factors affecting the efficiency of their activities. At the same time, such enterprises can execute both periodic and non-periodic orders. Their execution by interconnected BP is implemented by various sequences of actions. Typically, such processes compete for shared resources at various stages of the order fulfillment life cycle. Many departments, services and production units take part in the execution of orders. The order life cycle planning and regulation is directly performed by the planning department of the enterprise. The employees of the planning department introduce the next order into the plan for execution only when the correctness of its preparation and the availability of equipment and supplies has been confirmed.

The planning department defines the business process for completing an order, including its time schedule. The timeline indicates when each order stage will be executed. When a new order appears, the employee of the department faces the difficult task of determining the possibility of its implementation along with other executed orders. The decision depends on many factors. Among them are the availability of supplies, the condition of the required equipment, the availability of human resources as well as time constraints for both ongoing and new orders. The scheduler can determine the sequence of work that will be carried out on equipment (it is possible to combine some work with another similar order to save materials and preparation time). Therefore, the DM must plan, monitor, and manage the status of all executed orders of the printing industry. To fulfill orders within the time limits established by the contracts, he needs real-time information about the condition of the equipment, availability and sufficiency of materials and human resources. Since the DM controls the execution of all active orders at the enterprise, he needs to consider any detail that may become an obstacle to their fulfillment. The DM may directly change any priority (fixing the priority) of launching orders at the corresponding competitive point. The priority fixed by the DM at any competitive point cannot be automatically changed. Only the DM can change or delete the established priority. This is made so that the decision maker could change the priority of the orders at a competitive point, depending on the real-time conditions of the execution of a particular order. In particular, the manual priority change can be applied in case of incidents such as equipment failure, lack of materials, launching of a new order, etc.

Finding the required priority for orders launching at all competitive points is carried out by the DM using the developed software with four runs. If a sequence of priorities that satisfies the conditions for the remaining time was found during the current run, then it is considered optimal. At the following competitive points, the decision maker may continue using this <Solution> or search for other options that would satisfy the newly emerged conditions. Therefore, the advantage of using the developed software is that the DM can adjust the BP to the real-time conditions and restrictions that cannot be foreseen during planning. Moreover, the software set in "just in time" mode automatically adjusts previously obtained results based on modified existing or newly emerged conditions for launching orders. Those results are then used for subsequent analysis and the best option selection.

The main criterion for managing order fulfillment processes is to minimize the waiting time for orders to access shared resources. Untimely execution of one or another end-to-end business process/order leads to significant monetary losses. This fact directly affects the basic economic indicators of the enterprise. Therefore, the model, technology, and software tool <ADVISOR DECISION-MAKER> to be used by planners (DMs) will allow them to find optimal solutions that ensure the execution of orders on time, which directly improves the economic component of the "green economy". The impact of the obtained scientific results, namely, the proposed model and technology for defining the priorities of shared resources access is determined by the complexity of the planning and management of irregular, interconnected end-to-end BP. Existing methods, models and algorithms make it possible to solve main classes of tasks of calendar planning. However, it is difficult to implement them during the management of end-to-end BPs. Therefore, the use of the proposed model and technology and the software tool <ADVISOR DECISION-MAKER> allows the planner to find the optimal <Solution> for real-time management of multiple orders running simultaneously. The process of obtaining such decisions by the DM is considered on the example of determining the priorities of launching 3 printing orders competing for shared resources. The optimal launch priorities were found in accordance with the terms of the contracts. On-time fulfillment of all orders allows to improve the economic and social components of the enterprise, its level of innovation, stability and competitive ability in a dynamically changing market. Thus, this paper attempts to fulfill the research in improving the commercialization of enterprises in the field of Economics and Business.

## Conclusions

The general purpose of the article is devoted to the problem of the commercialization of research by using literature studies of existing approaches - environmental, economic and social models for the implementation of the elements of the main components of the "green economy". A harmonious combination of them makes it possible to obtain results that improve the social relations of both producers and consumers of goods and services. The implementation of these components is carried out by various projects. The project is carried out by irregular end-to-end BP competing for common resources in the process of their implementation. The impact on the components of the "green economy" is realized by the proposed model and technology. A decision is being formed on finding the optimal sequence of access for end-to-end BP to shared resources, with restrictions on the time they take to complete. The practical significance of the developed model and technology was conducted by the decision maker using the developed software tool <ADVISOR DECISION-MAKER>. It provides calculations on the necessary parameters for the implementation of projects and the determination of their priorities with subsequent adjustment.

## Conflict of interest

There are no conflicts to declare.

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