ECONOMIC METHODS OF REGULATING THE EQUIPMENT CONFIGURATION IN CONSTRUCTION

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Abstract. *The paper studies relevant issues of construction machinery import substitution and positive economic implications and some approaches to assessment of multiplier effects created by import substitution in construction. One of the most important problems in construction is a problem of efficiency growth of machinery assets (machines, plant, means of transport and equipment) utilization. And if before it was to use machines as much as possible to get a rise in productivity, then now construction companies have enough equipment and need more assessment of its efficiency, based on degree provision definition. Besides, taking into account last foreign-policy developments there is a high relevance of import substitution issue in domestic production, including construction. That is why there is a high significance of production and delivery of domestic machines that can provide independent process execution and technological development. Provision of construction sites with machinery has a row of important special aspects for such a big country as Russia. In Europe, the vast majority of construction projects with the exception of the Alpine region are located in a habitable and populated area where there is a good infrastructure. In Russia, on the contrary, the majority of construction projects is pioneering and builds up infrastructure. It takes some particular machine independence during the service life of the production facilities. The complexity of delivery of replacement parts, service teams and maintenance vehicles to constructions sites increases the risk of wasted time that leads to the decline of machine train economic indicators and construction lags. That is why in Russia there has been a priority in favor of repairable systems when there has been a maintenance capability in construction sites. The second feature of Russian construction machinery is the mobile character of connection between actual maintenance cost and estimated maintenance cost. Since Russian pricing is based on unit costs then technical recourses included into them are taken into account in the cost estimates. Estimated cost in its turn determines first contract cost in any tender. The practice of fixed price contract implementation does not make it possible for construction* *companies to take into account economic operational features of their own fleet of construction machinery. The goal of the research is to determine how parameters of equipment configuration affect the estimated cost, industry-specific and national economic indicators. The research is based on methods of retrospective statistical analysis with a representative selection of production figures. It made it possible to synthesize multiplying indicators that characterize being provided with construction equipment.*

Keywords: *construction machinery; import substitution; efficiency; cost; multiplier; economic effect.*

Introduction

About two-thirds of the estimated cost are expenses determined by the appropriate configuration of fixed assets. In modern construction, a great importance is attached to plant and equipment since the realization of infrastructure projects often depends on them. Besides, the choice of equipment determines not only investment volume but macroeconomic effect too. It needs to understand, that production norms are the source for estimate norms, that they take on the role of a measure of organizational and management decisions in production and have first-rate importance in construction regulatory regime improvement. Turnaround efficiency in the normative system is determined by choice of main points of fixed assets current status in construction.

These main points should be considered to be:
1. Operability of machine maintenance rates. All the stages of construction projects implementation take regularity in resource and cost indicators updating for the different degree of detail – for a construction company, for a construction site, for a construction crew and a construction machine. It means that standards are supposed to be structured according to the degree of consolidation and utilization during the construction process.

2. Economic feasibility. Different standard bases (federal, sector or company bases) elaboration and operating are to be unified with construction processes. Profit, profitability, expenses – these concepts may include both productive activity and standard-setting activity. On the one hand, standard-setting activity should be considered to be a separate investment project with its structure and expenses (noncurrent – for standard elaboration and current – for standards system maintenance). In this respect, standard-setting activity is like a consulting activity. On the other hand, standards are to include prerequisites and opportunities of construction operations activity and all of its subjects, including construction crews, investors, and the state budget. Taking all the construction process participants economic interest into account and providing cost-effectiveness indicators at an acceptable level determines the positive effect of investments into standards elaboration and implementation.

3. Information capacity. According to its content, shape and structure standards are to be a unified system with participants' access opportunities, information analysis and accumulation of data analysis opportunities, projection systems integration opportunities and process engineering integration opportunities. Standards updating procedure is not to be held since the very beginning, but through a context correction, providing cost saving.

4. Complexity. Standards support of construction is to be a system of resource and cost norms like all the stages of investment and construction project (from start to finish)) are to be unified. For construction production macroeconomic indicators assurance standard system is to operate unified indicators including labor movement indicators that are enlarged depending on target purpose of the standards. At the same time, there may be more modern construction needs and they are to be worked up more.

Taking it into account search and grounding of economic indicators of technical provision and recommendations creating for construction companies should be considered to be a relevant scientific issue. In modern Russian scientific literature problems of fixed assets either in different types of construction or in great construction projects are basically described. The relevance of conducted researches is a macroeconomic appraisal of construction fixed assets independent of interests of certain participants of the construction market. And that determined the purpose of the research – multiplier models development of sectoral production figures impact on macroeconomic indicators of economic growth.

Methodological approaches

The methodology of the research is based on economic approaches making it possible to estimate imported equipment availability in project recourses and analyze cost implications for construction projects.

This research identified specific features of the imported equipment impact on both technological and cost indicators. The influence of the applied imported equipment was differentiated by types of work and equipment range according to the methodology of estimated cost analysis (Solovyev, 2017). During further calculation of construction cost consolidated indices the difference of estimated cost under the multiplicative effect of the investigated factor reached in some cases even double overpricing comparing with the variant when all the works were completed only with domestic equipment.

There is an applied problem how to identify the connection between resources configuration factors of construction operations and macroeconomic implications. The solution of the problem is made by a multiplicative method which keeps the inherent functionality of the system, unlike a simple statistic description. It is relevant, including for the production process based on the described technological dependences.

Among three multipliers known in the modern literature (a multiplier factor, an operator of the chain economic reaction and a sequence of generated effects in other sectors) (Lukashev, 2003, pp.27-38) the following type of the multiplier was chosen to determine economic role of construction machinery import substitution:

$$M = \frac{I}{P+I};$$

I – construction machinery import substitution investments
P – profit for plant and machinery replacement with import-substituting production.

It is well known that nowadays construction only consumes production facilities, but do not produce them (Kaverzina & Lukovnikova, 2014, p.48), although in 70s – 80s of the last century construction companies created a lot of construction machines eliminating their scarcity. Since generally there was still a scarcity of construction machines any new asset had high indicators of utilization efficiency. This trend still exists in the current economic environment as well (Pankratov, 2012, p.75). That applied to the equipment of both factory production and construction companies own production.

On the basis of post-event analysis, it is possible to highlight 3 models of equipment utilization:
Model A (1973 – 1986 years): basically there was the provision of domestic machinery and creation of production facilities by construction companies if there was a scarcity of production facilities.
Model B (1990 – 2004 years): there was a significant decrease in domestic machinery production followed by a dramatic rise of import.
Model C (2005 – present time): Russian market saturation by both imported and domestic machinery.

Table 1, compiled on the basis of the data of Federal State Statistics Service (FSSS, 2018) and as a result of analyzing of a row of sources (Apatenko, 2015; Solin, 2011), presents return on assets (or capital productivity) ratios (in brackets – for machines produced by construction companies) and shift system factors K. As it is seen from the table 1, capital productivity of the irregular lifting appliances is much more than the same indicators for the machines produced in-state engineering factories.

Table 1. Machine utilization indicators in construction

The group of machines (the type of cranes)	Model A					Model B	Model C
	Percentage of production produced:			Average indicators			
	In factories of former USSR	Abroad	By construction companies	Capital productivity, R_a	Overage machine shift, K	Capital productivity, R_a	Capital productivity, R_a
Railway cranes	78	23		1.07	0.8	1.04	0.97
Semimobile cranes	84	13	3	1.12 (1.27)	1.4	1.03	0.86
Trestle cranes and pillar cranes	100			1.1	1.4	0.95	0.79
Tracklaying cranes	96	4		1.08	1.6	0.9	0.8
Jib cranes and special cranes with lifting ability less than 10 t	68		32	1.06 (1.42)	1.7	1.02	0.74

The representative selection was limited by construction projects with rotating scheme of work organization according to the statistics of transport construction sector. That time there were three sequenced budget-normative bases (1969, 1984 and 2001 years). But nowadays capital productivity indicators of building machinery of many Russian construction companies are even less than 1, that shows underuse of equipment in construction combined with high operating costs.

The authors' research in construction cost estimating showed that regulatory framework (both technical regulation and estimate norms) depends on engineering capability, facilities, and their conditions. In the research changes of indicators of fixed assets in use, utilization were analyzed. The period under report is the budget-normative base activity of the 2001 year. Taking into account that the base was introducing gradually with a considerable delay, the analysis of dependencies is performed including indicators of 2005 and later. The analyzed process is construction and transport machines capacity decrease because of their depreciation. The difference between standard capacity and working one determines the economic effect, while the standard technological capacity value is static. Conditional equality in standards initiation means correspondence of actual capacity and a standard one.

$C_{act}=C_{norm}$,
C_{act} – empirically defined actual sector average machine capacity (according to the types of machines).
C_{norm} – standard machine capacity

During the time of the operation of the standards the indicators of fixed assets in use change and break the equivalence – standard capacity does not change and actual one may both grow and fall due to machine train depreciation. According to the statistical data for the time of standard base validity the second case is more characteristic. The capacity proportions can be defined correcting the current average sector level of machine capacity.

$C_{fact}=C_{new}- C_{dep}*K\ (1-D)-DK_{dep}$
C_{new} – sector average level of machine capacity during the standard operation.
C_{dep} - degree of machine depreciation
D – share of worn out machinery
K, K_{dep}, - empirical proportionality factors

It is possible to calculate it knowing proportionality factors, showing declining dependence on depreciation degree (K) and full standard depreciation (K_{dep}). Taking into consideration research data about machine maintenance in construction it is possible to define K and K_{dep}, and it is also possible to conduct a conditional assessment of the correspondence of the actual and standard indicators of fixed assets in use at the sector level. The assessment is conditional because of the imperfection of production norm-setting. According to the Federal State Statistics Service data, the share of worn out fixed assets in construction is still on the quite a high level (table 2).

Table 2. Fixed assets of construction companies

	2005	2010	2011	2012	2013	2014
Fixed assets, billion roubles	264.3	703.9	906.3	910.5	944.5	1032.7
Fixed assets structure, billion roubles						
buildings, bil. rub.	26.2	23.3	20.4	21.7	22.4	24.6
structures, bil. rub.	9.9	13.7	16.3	13.8	14.0	12.4
machinery and equipment, bil. rub.	42.1	41.9	37.9	43.0	40.9	40.5
transport facilities, bil. rub.	18.4	18.6	22.9	18.9	20.2	19.8
other assets, bil. rub.	3.4	2.6	2.6	2.6	2.5	2.7
depreciation degree, %	42.0	42.5	38.7	44.2	47.1	47.3
percentage of worn out fixed assets	12.2	11.7	10.3	11.7	13.5	13.5

Economic effect E_m in the sector level is defined according to the criterion of estimation:

$$E_m=\sum_i^n P_{v-h,i} * (1-\Delta C_i) * Y_{mt} * N \quad ,$$

$P_{v\text{-}h,I}$ - Cost indicator of fixed assets in use, determined by standards. It is feasible to use standard vehicle-hour cost indicator for the macroeconomic purpose.
ΔC_i — The gap between the actual and the standard machine capacity
Y_{mt} — Annual fund of machine time, machine-hour
N — Number of units of the machinery

This approach for the effect definition has a disadvantage because it is averaged for construction work and means of equipment. But normative base contains a list in summary of machines and generalized parameters of their work calculating operating costs, that is why using standard and statistic indicators it makes baseline data population uniform.

The results of the calculation are presented in the table 3. Annual economic effect is determined for a particular case – railway cranes with carrying capacity – 10 t (railway construction).
Vehicle-hour cost=364,8 rub. in normative base prices of the 2000 year (table 3).

Table 3. Economic effect, defined by machine train production capacity

Indicator	Years			
	2000	2005	2010	2014
C_{dep},%	54.7	42	42.5	47.3
D	0.49	0.12	0.12	0.14
C^{act}	0.88	0.95	0.95	0.94
E_m, million roubles	26.3	10.3	10.7	11.5

Statistic data connected with machines that working life is over should be considered to be machines with an expired time of working life according to the depreciation rates. These machines transferred their cost to the cost of production and need to be changed, but machines renewal process has a low speed and there are no economic conditions for its renewal. The process of decrease of machine capacity due to the annual growth of repair and maintenance costs and wasteful expenditures of machine time was taken into consideration. For the proxy indicator return on assets can be taken, measured as a ratio of completed construction activity to the fixed assets value. For a description of functional relations between machine capacity and worn-out state, the values of K=0,08 and K_b=0,2 were used on the basis of return on asset ratio data according to Federal State Statistic Service and some construction companies.

The results of the calculations show that the economic effect is about 26 – 10 million roubles in a year. But in order to evaluate a real economic impact an economic effect of the base period should be taken into account. It is a specific feature of calculations based on base standards: all production and economic factors are taken into account by standards in the base period. In fact, due to the backlog of estimated standardizing from the construction technology, there is a significant margin in fixed assets conditions. And it is possible to make the methodology of economic effects calculation better. A formal approach determines the actual economic effect as:

$$E_m^{act} = E_m^{fact} - E_m^{stand}$$

E_m^{stand} – standard effect;
E_m^{fact} – practical effect

And then the actual effect will have the following values (table 4):

Table 4. The actual economic effect in sector cranes fleet

Indicator	Years			
	2000	**2005**	**2010**	**2014**
$\boldsymbol{E_m^{act}}$, million roubles	-	-16	-15.6	-14.8

Negative values of the effects show that standard machine capacity values are less than actual ones in the following years. Some economic stabilization after the 1990s let construction companies upgrade machine fleet and make the share of imported equipment more. Estimated machine maintenance cost was formed in conditions of considerable lags of used normal and in bad conditions when the Russian economy and technologies were at the beginning of a move in the right direction. In practice, effect size is distributed in estimated cost in projects where the machines of the considered group were used. The considered example creates opportunities for productive-economic indicators accounting as a factor of a choice of a base period in pricing.

Results of the research

The research showed that using import substituting domestic resources (construction machinery) causes macroeconomic results – effects that can generally be represented for different aggregation levels. To add to it there is a methodological analogy with the economic implications of substitute construction materials utilization (Korchagin, 2015). Aggregation levels can be economic indicators of revenue, GDP, national income and performance indicators of the sector and a company. Each of them is described by a set of investment activity components.

For example, the multiplicative relationship is described by the following dependencies:

1) Results and expenses: D=M*I
2) Economic effect and expenses: E=(M-1)M_iP_i
   P_i – revenue indicator
   M_i – multiplicative coefficient
   I – investments in construction

Calculations show that multiplier rose from 1.18 in 2001 to 1.43 in 2017 during the current budget-normative base existing.

It is well known that one of the main principles of the budget-normative base is its correspondence to the scientifically based process characteristic, installed according to the current level of technology development in construction. For the last 25 years, domestic machinery production degradation led to the common usage of foreign machines and equipment (Pankratov, 2012, p.76). At the same time, budget-normative base is basically oriented for the domestic machinery usage. This fact is supported by project owners (JSC "Russian Railways", for example) in order to prevent machine operating cost growth. When the authors were preparing estimating standards and rates and consolidated indices for railway construction in 2006 -2010 there was an opportunity to estimate maintenance cost of foreign machines and analyze its implication for an estimated cost of construction.

As the main hypothesis, the estimated cost dependence on maintenance cost was used. The calculation is connected with huge volume of cost accounting work, but for the only economic analysis its appliance is justified. The practical appliance is especially important for complicated and expensive machines such as tunneling shields, stripping equipment, cranes of greater load capacity. For these machines correlation ratios of estimated cost and cost per operator, hour were determined first. For the rest of the machinery, the calculation with components of expenses can be quite enough.
Based on the project data analysis of some great construction projects in Russia it was found, that three components of costs had the greatest density of correlation relationship:

R – repair and maintenance costs (correlation ratio – 0.71)
d – depreciation (correlation ratio – 0.94)
M – move costs (correlation ratio – 0.67)

It allows us to express the dependence as (Pankratov & Pankratov, 2015):

$$AM_i = k_r P_i + k_d d_i + k_m M_i$$

k_r, k_d, k_m – empiric functional ratios

The indicator AM_i describes the growth of the construction cost of an average construction object using a particular construction machine. It helps to make a choice of machinery in advance (on the stage of an expert judgment) taking into account its economic features.

In fact, indicator calculation at the sector level is possible only if there is an actual information system with large-scale integration like foreign tracking systems of the normative base (Means and so on) that could generalize current parameters of resources provision in construction. The foreign experience shows possibility in principle of data exchange about resource requirement among different construction companies. This information is generalized and used for both standard base maintenance and evaluation of the sector indicators (social cost level, sector growth dynamics, mastering of scientific progress results). There is no a system like this in Russia. Current systems of information centralization do not have an opportunity to calculate target indicators. It explains three obstacles for high precise calculation:

1. Accounting systems in big construction companies are not in line with each other. At the same time, accounting frameworks in different companies are not comparable and there is no payroll accounting in operating cost. Accounting reporting is not tied to machines and that is why sector indicators are not in line with resources in the standard base.
2. Federal State Statistic Service does not have an aim of information provision of economic calculations of specific sector indicators. Respectively set of parameters cannot be regulated according to requirements of standard provision system evaluation.
3. Federal authorities of government control, in particular, Ministry of Construction, do not have authorities for production data collection even for federal standard database maintenance. This function can be realized only as a special scientific work throughout tendering procedures. This procedure is unacceptable for systematic work.

Finally, it is worthwhile to say that the main levels of impact analysis should be considered to be a level of a singular resource that can be averaged as a group resource. In the rest of the levels, regularity of economic analysis of the standard base state takes new regulations for the creation of additional information of production process accounting.

Conclusions

The authors made a conclusion that machinery import substitution in construction may decrease expenses and make construction product cheaper, and at the same time provide an inflow of investments in machine-building industry and encourage scientific-and-technological advance in the future. The results of the research let us consider state programs of machine-building industry development justified. Besides, the effective way of shortage control of specific machines is their local production, which is proved by domestic construction experience.

As a matter of experience, every thousand euro invested in plant and equipment causes a discounted economic effect equal to 468 euro - in construction industry, 190 euro - in construction materials industry, 78 euro – in passenger transport, 70 euro – in raw materials industry. Obviously, besides, there is also a positive social effect. The results of the research let us consider machinery manufacturing government programs to be relevant.

The multiplier paradigms proposed by authors make it possible to estimate economic implications of facilities investments. To make the measurement of estimated cost change is possible thanks to AM_i indicator that recognizes the average paradigm of construction machines configuration.

The practical significance of the research makes sense not only for the construction industry. Putting the methodological recommendations into practice will also let investors make a right choice forming investment budgets for machinery manufacturing companies. Meanwhile, economic effects will cover many economic sectors – mining and manufacturing industries, transport, banking sector and social services.

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