INTERNATIONAL MONETARY FUND

# Public Investment Management Bottlenecks in Low-income Countries

Khaled Eltokhy, Nicoletta Feruglio, Kezhou Miao, Arturo Navarro, and Eivind Tandberg

**WP/24/232**



**2024**
NOV

WORKING PAPER

 WP/24/232

**IMF Working Paper**

Fiscal Affairs Department

**Public Investment Management Bottlenecks in Low-income Countries**

**Prepared by Khaled Eltokhy, Nicoletta Feruglio, Kezhou Miao, Arturo Navarro, and Eivind Tandberg***

Authorized for distribution by Juan Toro

November 2024



**ABSTRACT:** This paper uses principal component analysis (PCA) to identify bottlenecks to effective public investment management in LIDCs. The paper describes the current state of affairs regarding public investment and public investment management in LIDCs, drawing on the results of IMF Public Investment Management Assessments (PIMAs). PCA is used to analyze which public investment institutions are likely to be most important for investment efficiency estimates across the countries covered by PIMAs so far. Drawing on alternative input data, we identify five PIMA institutions that are systematically highly correlated to estimates of public investment efficiency in LIDCs and are likely to be high priorities in many PIM reform processes: Project management, Project appraisal, Procurement, Availability of funding, and Project selection. This does not mean that these five are the only important institutions – this will depend on country circumstances. The practical steps to strengthen PIM in LIDCs are elaborated in a separate How-to-Note.

JEL Codes: H54

Keywords: Public Financial Management; Low Income countries; Public Investment Management; Public Investment Management Assessment; Public Investment Efficiency

* “The author(s) would like to thank Cigdem Aslan, Ian Hawkesworth, Ed Hearne, Ryota Nakatani, Graham Prentice, Oni Raoilisoa, Carolina Renteria, Michelle Stone, Juan Toro, Alberto Tumino and Bryn Welham for valuable comments.

# Contents



BOXES



FIGURES

TABLES

# Glossary

| | |
|---|---|
| AE | Advanced economy |
| CEMAC | Central African Economic and Monetary Community |
| EME | Emerging market economy |
| GDP | Gross Domestic Product |
| GFC | Global Financial Crisis |
| LIDC | Low-income developing country |
| PC | Principal Components |
| PCA | Principal Component Analysis |
| PEFA | Public Expenditure and Financial Accountability |
| PFM | Public Financial Management |
| PIM | Public investment management |
| PIMA | Public Investment Management Assessment |
| SDG | Sustainable Development Goals |
| WAEMU | West African Economic and Monetary Union |

# Introduction

**Public investment is important for all countries but particularly for low-income developing countries (LIDCs).** Public infrastructure is critical for their ability to provide the population with basic public services, enhance climate resilience and achieve the United Nations Sustainable Development Goals (SDGs). The potential benefits of infrastructure investment are high, in terms of higher economic growth as well as improved living standards. Efficient and transparent public investment management (PIM) will also have positive impacts on the overall quality of governance, with repercussions to other parts of the public sector. However, countries with weak PIM fail to realize the potential benefits of public investment and mismanagement and corruption may be exacerbated.

**To realize the expected benefits of public investment, PIM must be efficient.** Inefficient investment has lower or negative impacts, as the multiple examples of resources wasted on “white elephants” – high-profile projects with high costs and questionable benefits – corroborate. Recent analytical work indicates that the average efficiency loss in public investment is estimated to be close to 34 percent across all countries, and the average efficiency loss in LIDC investments is estimated to be as high as 53 percent.[1,2] This means that on average, more than half the resources being channeled to public investment in LIDCs are wasted.

**This paper uses information gathered from more than eighty public investment management assessments (PIMA) across countries in all three income levels: advanced economies (AE), emerging market economies (EME), and LIDC.[3]** Relying on statistical analysis of this data set and the experience gained through the PIMAs, it identifies key bottlenecks to efficient PIM in LIDCs, as a basis for future reforms. The paper is organized as follows:

- The next section describes the current state of affairs regarding public investment and PIM in LIDCs. The discussion draws on the results of IMF PIMAs and on other relevant literature.
- The following section uses principal component analysis (PCA) to identify which public investment institutions are most important for investment efficiency in the countries covered by PIMAs so far.
- The final section summarizes the findings and provides some tentative recommendations for how the main gaps in existing PIM systems in LIDCs can be addressed. This reform agenda and the specific measures are elaborated in a separate How-to-Note.
- Annex 1 provides more detailed descriptions of the PCA analysis of PIM institutions and efficiency.

[1] Baum, Mogues and Verdier, 2020, Getting the Most from Public Investment, Ch. 3 (pp. 30 – 49), In: Schwartz, Gerd, Fouad, Hansen and Verdier, Well Spent: How Strong Infrastructure Governance Can End Waste in Public Investment (Washington DC: International Monetary Fund).

[2] The analysis is based on capital stock data and infrastructure outcome indicators from IMF Template of Investment and Efficiency for 2017 or a latest available year using the data envelopment analysis methodology, non adjusted for skewness.

[3] The dataset includes the PIMAs that had been completed by May 2023, excluding sub-national PIMAs and PIMA updates, and comprises 37 LIDCs, 39 EMEs, and 6 AEs.

# Efficiency of public investment

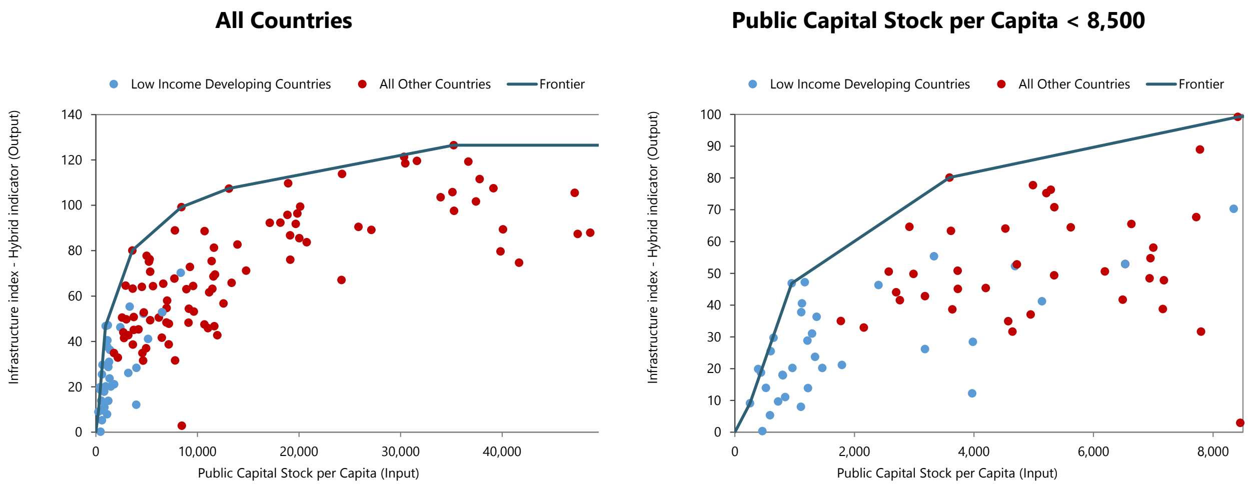
**The ability of a country to transform the same amount of resources into a larger volume or quality of infrastructure assets is a measure of public investment efficiency.** A widely used methodology for measuring efficiency is through benchmarking: comparing the outputs achieved by a country, specific sector or industry given a specific level of spending against the best performers. Recent IMF working papers have used this methodology to estimate investment efficiency using aggregated output.[4] and investment outputs of specific sectors [5]. Their analysis confirms that that there is a significant gain in infrastructure output to be gained from strengthening infrastructure governance. In particular, for LIDC and emerging markets the average efficiency gap is 53 percent and 34 percent respectively, with the gap for the former can be as high as 96 percent. The authors conclude that addressing the factors behind this inefficiency, for example, through better infrastructure governance, could increase infrastructure output by 65 percent in LIDC.

**The estimated efficiency of public investment varies dramatically between different countries and country groups.** Figure 1 illustrates efficiency frontier as of June 2022 for a wide range of countries based on a single input (public capital) and output (infrastructure outcome) model. The most efficient countries at any given level of public capital stock per capita are on the efficiency frontier. The distance from this frontier to each country indicates the efficiency gap, the potential infrastructure output that is lost due to various inefficiencies, such as weak PIM, complex topography, or corruption. The figure illustrates that many LIDCs have very significant efficiency gaps, reaching more than 60 percent in a few cases.

[4] Baum, Mogues and Verdier, 2020, Getting the Most from Public Investment, Ch. 3 (pp. 30 – 49), In: Schwartz, Gerd, Fouad, Hansen and Verdier, Well Spent: How Strong Infrastructure Governance Can End Waste in Public Investment (Washington DC: International Monetary Fund).

[5] Kapsoli, Mogues and Verdier, 2023, Benchmarking Infrastructure Using Public Investment Efficiency Frontiers (Washington DC: International Monetary Fund).

**Figure 1. Public Investment Efficiency Frontier – Hybrid Indicator**




*Source*: IMF Template for Investment and Efficiency (2022)

**The efficiency estimates are based on multiple factors with varying degrees of certainty and should be interpreted with caution.** Efficiency is measured through benchmarking, by comparing the performance of a country's infrastructure outcomes against the best performers, for a given level of spending. An illustrative example of inputs and outputs are the capital stock and the quality of infrastructure, respectively, but there are different models for estimating efficiency (e.g., parametric, non-parametric) and for measuring inputs and outputs.[6] Efficiency can also be measured separately for physical access and quality of public infrastructure. The definition of public investment varies across countries, in particular regarding investments by public corporations. If these are not included in the public investment definition, efficiency may be over-estimated compared to countries where public corporation investments are included. The analysis in this WP assumes that actual differences in public investment efficiency across countries is closely related to the differences in efficiency estimates.

## Public investment management in LIDCs

**The PIMA framework estimates the efficiency and assesses the institutional design and effectiveness of public investment in different countries.[7]** A PIMA estimates country-specific efficiency gaps and analyses the design and effectiveness of PIM institutions, covering 15 institutions comprising the planning, allocation, and implementation stages of public investments (figure 2). The assessment of institutional design focuses on the legal and institutional framework for public investment (de jure), whereas the effectiveness assessment looks at how this is applied in practice (de facto). The

[6] Baum, Mogues and Verdier, 2020, Getting the Most from Public Investment, Ch. 3 (pp. 30 – 49), In: Schwartz, Gerd, Fouad Hansen and Verdier, Well Spent: How Strong Infrastructure Governance Can End Waste in Public Investment (Washington DC: International Monetary Fund).

[7] Public Investment Management Assessment — Review and update, IMF 2018.

PIMA uses a three-tier scoring methodology (low-medium-high or 1-2-3) to assign scores to each of the 15 institutions. The PIMA framework provides a basis for defining reform programs for public investment and it has now been applied in about 89 countries, including 37 LIDCs.[8]

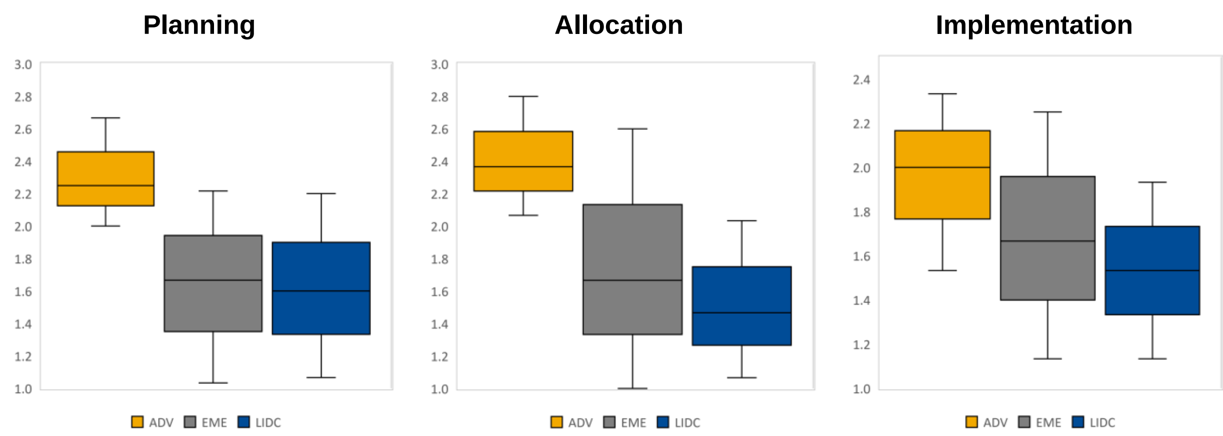
**Figure 2. The PIMA framework**


Source: IMF, Public Investment Management Assessment—Review and Update, 2018.

**Most LIDCs receive relatively low PIMA scores.** The average PIMA effectiveness score for LIDCs is marginally above 1.5, which is the threshold for a low rating (implying that basic requirements are not met) in the three-tier PIMA scoring methodology (Figure 3).[9] This result holds for each of the three phases of the project cycle identified in the PIMA, with scoring being lowest in the allocation phase. On average, LIDCs also perform below countries in other income groups, though the difference with EMEs is not as significant as with advanced economies. This is particularly true for the planning phase in which the average score for LIDC is slightly below that for EMEs and the best performer is just as good. It is also worth noting that LIDCs receive at best an average effectiveness score of medium, with no country achieving a high rating for any of the three phases. LIDC scores for institutional design are higher as will be discussed further ahead.

[8] The working paper utilizes the results of 82 PIMAs, as exercises at a sub-national level or repeat PIMAs are not considered for the analysis.
[9] The PIMA questionnaire defines three levels of practice – low, medium, high – for the three dimensions under each of the 15 institutions. A country's regulatory framework and its application are assessed on how well they meet the criteria under each level and a simple average is estimated for each of the 15 institutions.

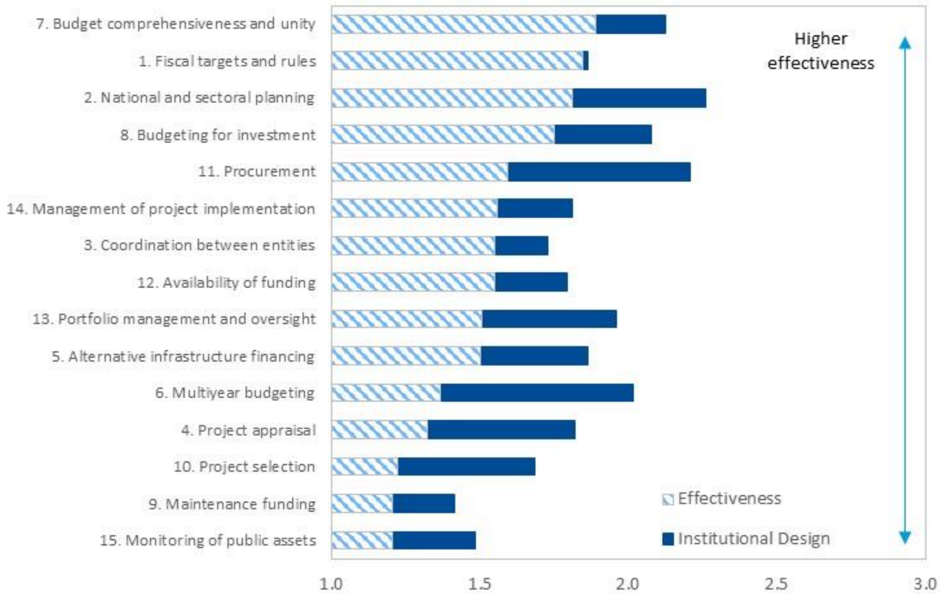
**Figure 3: Average PIMA scores by phase and income group (effectiveness)**




Source: IMF PIMA database.
Note: The graphs show various efficiency scores for each income group (37 LICs, 39 EMEs, and 6 AEs): top and bottom of lines show max and min efficiency score for a country in the sample; top and bottom of the box show the third and first quartile score; the line within the box shows the median score for the income group.

**The assessed PIMA scores vary greatly across institutions and between design and effectiveness.** Average institutional design scores for LIDCs are 22 percent higher than effectiveness scores – 1.9 vs. 1.5, respectively, with the largest difference being in *multi-year budgeting*, 47 percent – 2.03 vs 1.37. Moreover, there are two institutions whose score drops significantly when comparing design and effectiveness: *multiyear budgeting* and *project appraisal*, which have a medium score (2.03 and 1.82, respectively) in institutional design but are among the least effective institutions (1.37 and 1.32, respectively). There are three institutions with the lowest performance for both institutional design and effectiveness: *project selection, maintenance funding and monitoring of public assets*. For effectiveness, the institution with the highest score is *budget comprehensiveness* (1.89) which is 56 percent higher than *monitoring of public assets* which received the lowest score (1.21). Three institutions in the allocation phase receive very low scores, underscoring the difficulties faced by LIDCs to appropriately assign resources for building and maintaining assets. Figure 4 gives an overview of average PIMA scores in LIDCs.

**Figure 4: Average PIMA scores for 37 LIDCs (sorted by effectiveness scores)**




Source: IMF PIMA database.

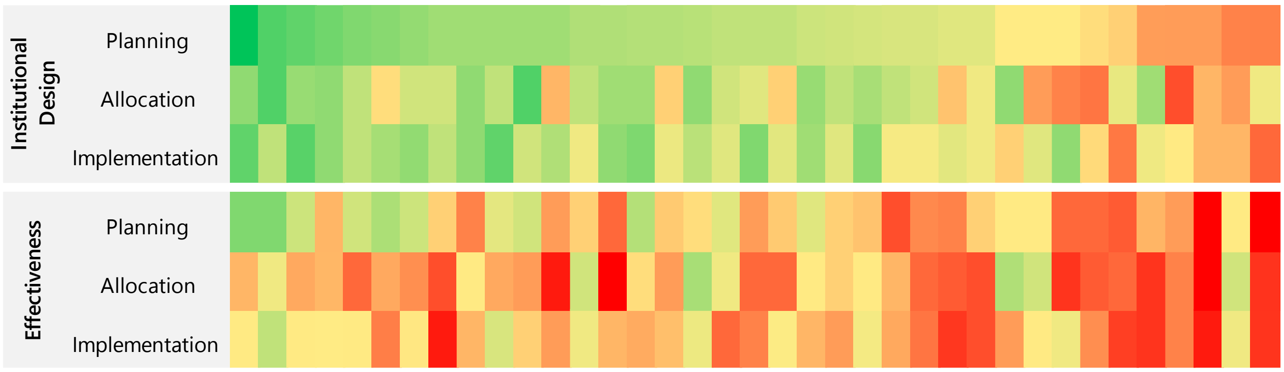
**On average, LIDCs score relatively better in institutional design than in effectiveness across all PIMA institutions**. This is a general feature in PIMAs, reflecting that it takes considerable time for new institutional frameworks to become effective. LIDCs are primary receivers of capacity development support from the development community, among which there is an emerging consensus on the institutions and practices needed to strengthen public financial management (PFM) and PIM.[10] The participation of LIDCs in regional institutions — such as CEMAC or WAEMU for Central and West African countries, respectively — which establish common norms and directives for member countries, can also be a catalyst for reforms for some countries. These factors underpin stronger legal and regulatory frameworks that are aligned with regional directives and international good practice, which create a stronger institutional foundation. This may also help explain why LIDCs perform poorly in other areas that can be more country specific, such as maintenance funding and project selection, which are not covered by regional directives and where the international consensus on good practices is less developed.

**Some LIDCs do considerably better than the average in the PIMA assessment**. While average PIMA scores for LIDCs are low, there is considerable variability among the 37 LIDC PIMAs that have been completed. Particularly institutions in the Planning Phase appear to be the strongest, with some cases of high PIMA scores in effectiveness, which are predominantly in this phase. In contrast, those in allocation are the weakest for both institutional design and effectiveness. The low effectiveness score of the allocation phase underlines the challenge countries face to ensure public investments are allocated the appropriate funding both during implementation and operation. Figure 5 provides a heat map of country

[10] As demonstrated by the development of the PEFA (2016) and PIMA (2018) frameworks.

scores, indicating how scores compare between institutional design and effectiveness and across phases of the project cycle.[11]

**Figure 5: Heat map of PIMA scores for 37 LIDCs**




Source: 37 PIMA reports.

Note: Individual columns represent anonymized country scores, which are ranked per the average institutional design score for Planning. Colors represent the scoring of the PIMA on a scale of 1 -3, with 3 being highest and represented by Green and 1 the lowest in red. Different shades of colors are used to highlight differences between countries.

**The relatively lower effectiveness result illustrates the challenges faced by countries when implementing PIM, and more generally, PFM reforms.** There is increasing consensus on the institutions, practices and tools that are needed in many of these areas. This emerging consensus is reflected in literature, education of civil servants and in public policy actions suggested by the development community, governments with advanced practices, and the private sector. Regulatory frameworks and institutional setups can be updated to adopt much of the proposed improvements in this consensus. However, limited technical capacity and staff availability may undermine the authorities' success at implementing these "strong" regulatory frameworks. The limitations call for stronger attention for designing reform plans, both in setting objectives that can realistically be achieved and in defining the appropriate timeframe within which the reforms should be implemented. A recent FAD How-to-Note discusses how to define and implement PIM reform agendas in LIDCs.[12]

[11] To bring out the nuances between countries, the heatmap uses a more granular color-coding scheme than the standard three-level PIMA codes. Instead of a 3 color (red-yellow-green) step scale, we use a diverging scale, where the lowest and highest scores in each phase are assigned the two ends of the diverging color scale. Because many of the reports are not published, the table does not include country names.

[12] HTN 24/xx., IMF, 2024.

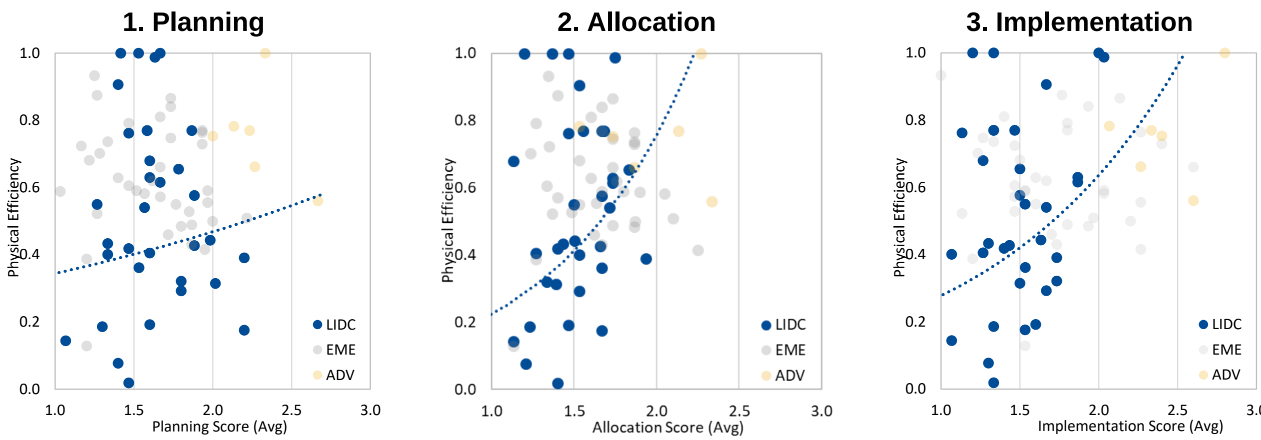
# Identifying the bottlenecks in PIM capacity and efficiency

**This section describes the quantitative analysis undertaken to identify which PIMA institutions have most impact on efficiency in LIDCs**. The objective is to understand if there are empirically robust correlations between the observed differences in PIM efficiency or outputs and the capacities described in the preceding section. This is important for prioritization of PIM reforms in countries with limited capacities.

## Quantitative analysis

**PIMA scores suggest that stronger PIM is correlated with higher public investment efficiency.** Figure 6 illustrated that on average LIDCs lag on all measures of effectiveness across the three phases of the PIM process, with a few LIDCs scoring within the average for EME or AE. Figure 6 suggests a positive correlation between countries' average scores for each PIMA pillar (horizontal axis – 3 implies high score) and the estimated physical efficiency level (vertical axis – 1 implies no efficiency gap).[13] We see that countries with higher PIMA scores generally are much closer to the efficiency frontier. Figure 7 indicates that there is a similar, but somewhat weaker correspondence between PIM capacity and quality efficiency for at least two of the PIM phases.[14]

Figure 6: Correlation between PIM capacity and physical efficiency

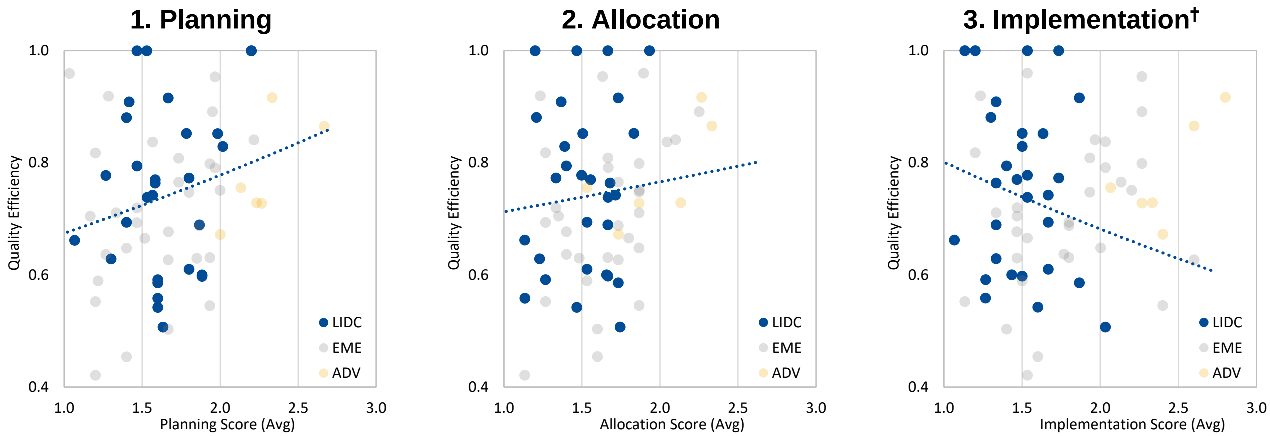



Source: IMF PIMA database, IMF Template of Investment and Efficiency (2022).
Note: Trendline is only for LIDCs.

[13] Physical efficiency refers to the relationship between public capital stock and physical access to infrastructure.

[14] Quality efficiency refers to the relationship between public capital stock and perceived quality of infrastructure.

**Figure 7: Correlation between PIM capacity and quality efficiency**




Source: IMF PIMA database, IMF Template of Investment and Efficiency (2022).
Note: Trendline is only for LIDCs.
†The trendline in this graph shows a negative correlation between quality of efficiency and the PIMA scores in implementation. This result is counterintuitive because it implies that countries with better practice in the stage of project implementation are less efficient. The result appears to be driven by 4 countries that have a very high quality efficiency score - close to 1 - but a low implementation score. As these countries are included in the database for the PCA analysis it was decided to leave them within this graph.

**The graphical representations illustrate several points regarding the correlations between PIM effectiveness and public investment efficiency.**

- The trendlines for LIDCs confirm a positive relationship between PIM and physical investment efficiency, especially in the allocation and implementation phases. The strongest correlation appears to be for the allocation phase, during which budgeting of public investments and maintenance expenditure are assessed.

- The correlation between PIM and investment efficiency is weakest in planning, likely driven by the low scores in the institutions of project appraisal and coordination between entities, where 75 and 50 percent of assessed countries, respectively, received a low score.

- The correlation is clearly stronger for physical efficiency than for quality efficiency. There is a moderate positive correlation between the planning and allocation institutions and quality efficiency. However, the data indicate a negative correlation for the implementation institutions. This is counter intuitive. It could be spurious, or it could imply that public perceptions of infrastructure quality are more impacted by plans and budget allocations than by actual implementation progress.

- Annex 2 presents the same graphs as in figure 7 excluding some countries that could be outliers. These countries have very high efficiency scores with very weak PIMA ratings or low efficiency with strong ratings. When the possible outliers are removed the results are more intuitive.

## Using PCA to reconstruct the PIMA scores

**Since more effective PIM is expected to support more efficient investment, it is important to identify where the most significant inefficiencies lie and design reform plans to tackle these.** The PIMA framework comprises 3 phases of the PIM process divided into 15 institutions. The scores at the phase level in figures 6 and 7 are calculated as a simple mean of the 5 institutions in each phase. Using a simple average has the advantage of being simple to interpret, but it has the disadvantage of losing out on variations within institutions in the same phase. Additionally, the PIMA questionnaire is highly detailed, and when used in statistical analysis, the problem of multicollinearity cannot be avoided (i.e. that PIMA scores at the institution level are highly correlated).

**To address this, Principal Component Analysis (PCA) is used to construct new, uncorrelated variables that are used in the statistical analysis**. PCA is a statistical technique that takes a set of correlated variables and transforms them into uncorrelated variables called principal components (PCs).[15] Principal components can be interpreted as weighted averages, or linear combinations of the original variables, with each new principal component explaining some unique variation in the data. The principal components are ordered by decreasing importance, meaning that the PCs with the greatest explanatory power will come first in the order. Box 1 describes the process followed in the PCA to identify the PIMA institutions that are most relevant to achieve a higher level of PIM effectiveness.

### Box 1. Using PCA to identify key PIMA Institutions

The statistical analysis used in this working paper involves two stages. The purpose of the first stage is to implement a two-step PCA to produce new uncorrelated variables – Principal Components (PC) – comprised of the most relevant PIMA institutions for PIM effectiveness. The purpose of the second stage is to validate whether the institutions selected in the first stage can predict the PIM efficiency and output scores for LIDC countries. The PCA approach is applied to three different data sets:

1. Effectiveness of PIMA institutions in 37 LIDCs.
2. Effectiveness of PIMA institutions in 82 countries.
3. Same data as in scenario 2, but first stage results are adjusted for experience.

**First stage (Institution identification)**

The first stage does a two-step PCA using the effectiveness scores for all 15 PIMA institutions to identify those that have the most impact on PIM effectiveness, according to the data. The number of PCs that the analysis generates is the same as the number of variables (15 in the first step) and produces two sets of results for each PC: 1) Proportion – how much of the variance in the data each PC explains, and 2) Loading – how much each variable (institution) contributes to each principal component. For each variable-PC pair, the proportion of the PC is multiplied by the loading of the variable (institution) to this PC, and these calculated numbers are ranked from largest to smallest

[15] For an overview of PCA see Principal component analysis: a review and recent developments, Ian T. Jolliffe and Jorge Cadima, 2016.

(ranking number). The second step PCA uses those variables (institutions) that appear most significant in the first step to construct a new set of PCs*; which are the ones used in the second stage (validation).

Additional combinations of variables (institutions) can be created by using different input data and by adjusting the direct results of the first stage PCA to reflect experience and judgement. The initial set may include institutions that seem counter-intuitive, while institutions considered to be critically important may be missing. Any adjusted sets of institutions are included in the PC*s from the second step PCA to be validated in the next stage.

In the first step PCA, the first 7-9 PCs explain 77-88 percent of the variance in data. The top 7-9 variables (institutions) with the highest-ranking number are considered the most relevant and selected for the second PCA analysis. The number of variables selected (7-9) is by design and can be modified. To test whether adding more variables led to better results during the validation stage, the top seven variables (institutions) were selected for data sets one and three and the top nine were used for data set two. The second step of the PCA uses the 7-9 selected variables that seem to have the most impact on PIM effectiveness to construct a new set of PCs*. The first three PC (PC1*, PC2* and PC3*) explain between 68 and 76 percent of the variance in the data. The loadings* of the institutions help identify which institutions (among the 7-9 institutions) are most relevant to each PC*. These three PCs* are used as independent variables in the regressions of the validation stage (stage 2).

**Second stage (validation)**

In this stage the dependent variables from the PIMA data set (hybrid efficiency, physical efficiency, and quality efficiency) are regressed on the same independent variables PC1*, PC2*, and PC3* constructed from the institutions selected in the first stage, to determine if the coefficients of the PCs* are statistically significant. An LIDC dummy variable (LIDC = 1, Others = 0) is included in the regressions when data sets covering all PIMAs are used. The significance levels indicate how robust the correlations between the PIMA institutions included and the efficiency measures are. The regressions are done separately for data sets 1, 2 and 3. This serves to validate whether the variables identified as relevant through the PCA analysis, and the experience-based adjustments are reasonable.

To further assess the validity of our analysis, indicators for public investment output (hybrid output, infrastructure access and infrastructure quality) were regressed against PC1*, PC2* and PC3*. These regressions test whether the absolute level of public investment output in a country is correlated with PIM effectiveness, without consideration of difference in public capital stock. If there are inconsistencies in capital stock comparisons across LIDCs, for instance due to the volume of off-budget investment activities, the regressions against output levels may also be relevant for this analysis.

## Priority PIMA Institutions

**The PCA helps identify the PIMA institutions that are the main bottlenecks to public investment efficiency**. The analysis uses PIMA effectiveness data sets to determine the institutions that best predict investment efficiency in these countries (Box 1). Three different scenarios for the PCA were constructed by varying the input data sets.

**Scenario 1 is based on effectiveness data for the 37 LIDCs covered by PIMAs so far.** The PCA found that institutions across the three phases of the project cycle were relevant for achieving higher investment efficiency levels, but institutions related to the implementation phase dominated. Institutions with a high loading within PC1* are likely to be more relevant to explain the efficiency levels (PC1* explains 51 percent of the total variance). The results indicate that LIDCs with stronger practices for *project appraisal, project management, availability of funding, procurement,* and *project selection* tend to have higher efficiency scores, as expected. PC1* also indicates that public investment efficiency in LIDCs is correlated to *alternative infrastructure financing* and to *Monitoring of public assets*. Table 1 describes the institutions within PC1*, PC2* and PC3* that are more related (higher loadings) to investment efficiency following the initial analysis of LIDC PIMA data.

**Table 1: Priority PIMA Institutions Identified by PCA – Scenario 1**

| PIMA-PC1* | PIMA-PC2* | PIMA-PC3* |
|---|---|---|
| 4. Project appraisal | 15. Monitoring of public assets | 5. Alternative Infrastructure Financing |
| 14. Project management | 10. Project selection | 4. Project appraisal |
| 12. Availability of funding | 12. Availability of funding | 14. Project management |
| 11. Procurement | 4. Project appraisal | 11. Procurement |
| 10. Project selection | 11. Procurement | 12. Availability of funding |
| 5. Alternative Infrastructure Financing | 5. Alternative Infrastructure Financing | 10. Project selection |
| 15. Monitoring of public assets | 14. Project management | 15. Monitoring of public assets |

Note: The three PCs presented in this table explain cumulatively 75 percent of the variability in the data. The institutions without shades within each PC are the ones that are highly related to each PC, and those shaded in grey are considered not highly related to each PC – loadings below 0.25). Institutions are ranked by loadings from largest to smallest.

Source: Staff estimates, IMF PIMA database.

**Scenario 2 is based on effectiveness scores and efficiency estimates for 82 countries covered by PIMAs.**[16] The purpose of using this data set is to see whether there are systematic differences in which institutions have most impact on efficiency between LIDCs and other countries. Additionally, in this scenario the number of variables used in the second step PCA was increased to nine to test whether adding more variables significantly changes the results. The results show that the explanatory power of PC1* is slightly lower than in scenario 1 (48 percent of the variance in the data), but the top five institutions are the same and only one changes in the first seven: *portfolio monitoring* replaces

[16] This excludes PIMA updates and subnational government PIMAs.

*monitoring of public assets.* This indicates that the most critical institutions tend to be similar across different country groups. *Coordination between entities* and *maintenance funding* are the last two variables (institutions) that came up as relevant by increasing the number of variables from seven to nine. In addition, the relative importance of the different institutions changes somewhat. It is important to note that these results apply to the groups on average, and there is likely to be much more significant differences between countries. Because PC2* and PC3* explain variance in the data not captured by PC1*, the change in PC1* institutions also changed the composition of PC2* and PC3*. The overall explanatory power of PC1* to PC3* was reduced to 68 percent. Table 2 describes the institutions that were included in PC1*, PC2* and PC3* following the analysis of PIMA data across country groups.

**Table 2: Priority PIMA Institutions Identified by PCA – Scenario 2**

| PIMA-PC1* | PIMA-PC2* | PIMA-PC3* |
|---|---|---|
| 14. Project management | 10. Project selection | 3. Coordination between entities |
| 4. Project appraisal | 9. Maintenance funding | 13. Portfolio monitoring |
| 12. Availability of funding | 13. Portfolio monitoring | 14. Project management |
| 11. Procurement | 4. Project appraisal | 5. Alternative Infrastructure Financing |
| 10. Project selection | 5. Alternative Infrastructure Financing | 12. Availability of funding |
| 13. Portfolio monitoring | 3. Coordination between entities | 10. Project selection |
| 5. Alternative Infrastructure Financing | 12. Availability of funding | 4. Project appraisal |
| 3. Coordination between entities | 14. Project management | 9. Maintenance funding |
| 9. Maintenance funding | 11. Procurement | 11. Procurement |

Note: The three PCs presented in this table explain cumulatively 68 percent of the variability in the data. The institutions without shades within each PC are the ones that are highly related to each PC, and those shaded in grey are considered not highly related to each PC – loadings below 0.25). Institutions are ranked by loadings from largest to smallest.

Source: Staff estimates, IMF PIMA database.

**In scenario 3, the PCA results for the 82 PIMAs were complemented to reflect on-the-ground experience.** There are some specific PIMA institutions that repeatedly have been identified as critical components of a strong PIM framework.[17] Most of these came up in the results of the PC analysis, but a few were missing. *Multi-year budgeting* and *maintenance funding* are the two clearest examples. It is very difficult to plan and effectively implement a multi-year public investment program in the absence of at least a rudimentary medium-term budget process, even in an LIDC. And the quality of public infrastructure is completely dependent on whether it is adequately maintained. To reflect these considerations, a third set of PCs were designed with PIMA institutions *maintenance funding* and

[17] Public Investment Management Assessment—Review and Update, IMF, 2018

*multiyear budgeting* replacing institution *alternative infrastructure financing* and *portfolio monitoring*, the two least intuitive institutions, which also had a low loading score in the analysis of scenario 2. Table 3 summarizes the institutions included in PC1*, PC2* and PC3* in scenario 3. This adjustment increased the proportion of the variance in the data explained by PC1* to 51 percent. Because PC2* and PC3* explain variance in the data not captured by PC1*, the change in PC1* institutions also changed the composition of PC2* and PC3*. The overall explanatory power of PC1* to PC3* increased to 76 percent.

**Table 3: Priority PIMA Institutions adjusted – Scenario 3**

| PIMA-PC1* | PIMA-PC2* | PIMA-PC3* |
|---|---|---|
| 14. Project management | 6. Multiyear budgeting | 9. Maintenance funding |
| 4. Project appraisal | 4. Project appraisal | 6. Multiyear budgeting |
| 11. Procurement | 10. Project selection | 10. Project selection |
| 12. Availability of funding | 11. Procurement | 12. Availability of funding |
| 10. Project selection | 9. Maintenance funding | 4. Project appraisal |
| 9. Maintenance funding | 14. Project management | 11. Procurement |
| 6. Multiyear budgeting | 12. Availability of funding | 14. Project management |

Note: The three PC presented in this table explain cumulatively 76 percent of the variability in the data. The institutions without shades within each PC are the ones that are highly related to each PC, and those shaded in grey are considered not highly related to each PC – loadings below 0.25). Institutions are ranked by loadings from largest to smallest.

Source: Staff estimates, IMF PIMA database.

**The PCA provides valuable insights on where PIM reforms could have the most impact on investment efficiency in LIDCs**. There are five variables with high loading scores when running the PCA for both the full country sample and only LIDCs. These are: *project management, project appraisal, procurement, availability of funding, and project selection*. This result is consistent with the experience gathered from PIMA assessments. The analysis also identifies other institutions that appear to play a role, but the loading scores from the PCA are not very strong and changes in the data set affect their level of relevance. These institutions are *coordination between entities, alternative infrastructure financing, multiyear budgeting, maintenance funding, portfolio monitoring, and monitoring of public assets*. The following section uses multiple linear regressions to identify which PIMA-PC* variables are statistically significant for predicting the efficiency and output indicators of public investment**.**

## Validation of PCA results

**The outcomes of the linear regressions support the conclusions reached through the PCA of the institutions that appear to have the strongest relationship with efficiency and output indicators for public investment.** The variable PIMA-PC1* was significant for explaining the variance of at least one of the efficiency or output indicators across all three scenarios; as discussed before, for each scenario, the five institutions with the highest loading score in PIMA-PC1* were project management, project appraisal, procurement, availability of funding and project selection – though with varying order. Similarly, if these five institutions had low loadings in the constructed PIMA-PC2* and PIMA-PC3* these PCs were not significant in most of the regressions.

**The results of the regressions also suggest that the other six institutions identified in the PCA exercise are important but are not as relevant as the five mentioned before.** Although they are included in at least one of the PIMA-PC1* variables, these variables normally had low loadings, which mean that their contribution to the new PC variable was not that relevant. Also, when these variables replaced one of the five key institutions within a PC these PCs were not as significant. For example, the variable PIMA-PC-3* in Scenario 2, in which the first two institutions with the highest loading were *coordination between entities* and *portfolio monitoring,* was not significant for predicting any of the output or efficiency indicators.

**Adjusting the institutions in the PCA to reflect the experience of the eighty-plus PIMA completed does not improve the predictive capacity of the PCs.** In Scenario 3, *maintenance funding* and *multiyear budgeting* were included in the second step PCA based on PIMA experience and judgement, even though they had a lower loading score than *portfolio monitoring* or *alternative infrastructure financing.* The regressions results are very similar to the results for scenario 2. This implies that the exchange of PIMA institutions with lesser weight in the PCA has little impact on predicting public investment effectiveness. Thus, the results cannot be used to identify which of the institutions that differ between Scenarios 2 and 3 are most impactful.

**Table four presents a summary of the PIMA-PC* variables that can be considered significant to explain the variation in public investment efficiency and output indicators.** Annex 1 presents the detailed regression results for each scenario for each indicator. The following observations arise from this table:

- PIMA-PC1* is the variable that is the most significant for explaining the variation of public investment indicators; it plays a significant role in 12 of 18 regressions.
- The relevance of PIMA-PC1* appears to be strongest in Scenario 3, which is adjusted for experience to include maintenance funding and multiyear budgeting, for both efficiency and output indicators.
- The relevance of PIMA-PC1* seems to improve when the full data set of information for all countries is used (Scenario 2), instead of only the LIDC (Scenario 1).
- When *monitoring of public assets* has a high loading score (Scenario 1 – PIMA-PC2*) the PC does not appear to have a strong relevance. A similar conclusion applies to *alternative infrastructure financing* (Scenario 1 – PIMA-PC3*).
- When *multiyear budgeting* has a high loading score (Scenario 3 – PIMA-PC2*) the PC does not appear to have a strong relevance. A similar conclusion seems to surface for *maintenance funding* (Scenario 3 – PIMA-PC3*) which shows limited relationship with efficiency our output indicators.

- The LIDC indicator variable has strong and significant impacts on all three output indicators in Scenarios 2 and 3, illustrating the systematically lower level of investment outputs in LIDCs.
- The observation that the LIDC indicator is not relevant for efficiency indicators implies that the differences in efficiency are largely related to the specific PIM institutions, rather than to the fact that the country is an LIDC in itself.
- Regression results against investment outputs have higher statistical significance than the regressions against efficiency.

**Table 4: Summary Regression Results – Significance of PIMA-PC* Variables vs. Public Investment Efficiency and Output Indicators**

| | Efficiency Indicators | | | Output Indicators | | |
|---|---|---|---|---|---|---|
| | Hybrid | Physical | Quality | Hybrid | Physical | Quality |
| *Scenario 1* | | | | | | |
| PIMA – PC1* | *** | | | *** | | *** |
| PIMA – PC2* | | | * | | * | |
| PIMA – PC3* | | | | ** | *** | |
| *Scenario 2* | | | | | | |
| PIMA – PC1* | *** | | ** | *** | *** | |
| PIMA – PC2* | | ** | | *** | *** | |
| PIMA – PC3* | | | | | | |
| LIDC+ | | * | | *** | *** | *** |
| *Scenario 3* | | | | | | |
| PIMA – PC1* | *** | | * | *** | *** | *** |
| PIMA – PC2* | | | | ** | | |
| PIMA – PC3* | | ** | | | ** | |
| LIDC+ | | ** | | *** | *** | *** |

Source: IMF staff estimates, IMF Template of Investment and Efficiency (2020), IMF PIMA database.

Note: “ * “ identify the variables that are significant at a 90 percent (*), 95 percent (**) or 99 percent (***) confidence.

+/ LIDC is a dummy variable identifying low-income developing countries. If country is LIDC, its value is 1, otherwise 0.

# Addressing the bottlenecks – priority reform agenda

**The analyses in previous sections indicate clear links between the effectiveness of public investment management and the estimated outputs and efficiency of public investment**. While there also are other explanations for the current weaknesses in public investments in many LIDCs, including political and macroeconomic constraints, our analysis indicates that improvements in management capacities is likely to have significant, positive impacts on infrastructure access, quality and efficiency. This conclusion is also supported by other IMF analytical work on investment efficiency.[18]

## Main gaps in LIDC PIM systems

**The PCA supports the notion that five PIMA institutions have a significant impact on overall public investment output and efficiency, both in LIDCs and in other country groups**. These institutions are *Project management, Availability of funding, Project appraisal, Procurement, and Project selection*, which occur in all the PCA scenarios based on alternative assumptions. This is in line with expectations and with practical experience from country engagements. If we refer back to the three PIMA phases discussed in the beginning of the paper, we see that 1 of the five institutions belongs to the planning phase, one to the allocation phase, and the remaining three to the execution phase.

**Improvements in the five institutions can be identified as high priorities in many PIM reform processes, and particularly in LIDCs**:

- **Project appraisal** is necessary to assess the strategic importance and the expected costs and benefits of an investment project, as well as its readiness for implementation. If this is not adequately analyzed and documented, decision-makers will not be able to ascertain if there is the necessary basis for effective project implementation or to ensure that projects can achieve key strategic objectives and maximize net benefits.
- **Project management** should ensure that projects are implemented in accordance with budget, timetable, and specifications. This requires well-defined implementation plans and clear accountability for successful implementation. It is essential that the project is fully prepared, and that all necessary permits are secured prior to project implementation. Otherwise, the likelihood of delays and cost escalation is very high.
- **Procurement** is critical to ensure that the planned project objectives are realized and avoid corruption and other governance issues during the procurement process. To facilitate this, procurement should be open and competitive, and the process should be transparent. Attempts to circumvent procurement regulations, for instance by limiting potential bidders, will generally lead to delays and to inferior proposals being selected.
- **Availability of funding** is a major bottleneck in many LIDCs, where the capital budget is often used as a fiscal buffer. In-year fiscal resources may be severely constrained due to unrealistic revenue projections and unplanned expenditures. Weaknesses in cash forecasting and management may lead to cash rationing and arrears, undermining the credibility of funding for ongoing investment projects. Ineffective coordination with external funding and financing sources may exacerbate these challenges.

[18] Baum, Mogues and Verdier, 2020, Getting the Most from Public Investment, Ch. 3 (pp. 30 – 49), In: Schwartz, Gerd, Fouad, Hansen and Verdier, Well Spent: How Strong Infrastructure Governance Can End Waste in Public Investment (Washington DC: International Monetary Fund).

[18] Kapsoli, Mogues and Verdier, 2023, Benchmarking Infrastructure Using Public Investment Efficiency Frontiers (Washington DC: International Monetary Fund).

- **Project selection** should ensure that the projects with the highest likelihood of achieving strategic objectives and the highest net benefits compared to costs are prioritized, that projects to be implemented are fully prepared and that they are consistent with available resources. In the absence of a systematic project selection process, project results will be uncertain, the value of the public investment portfolio will be arbitrarily determined and often unknown, and project implementation will often be delayed**.**

**Building capacity in these five institutions requires acquiring skills that differ from those needed for managing current government expenditure.** Infrastructure projects are likely to be very different, and even within the same sector no two projects will be identical. This implies a much higher level of uncertainty than for current expenditure and this make effective capital project implementation more difficult. Large infrastructure projects may be infrequent, making it difficult to build capacity through repetitive processes. In an LIDC, there may be few large infrastructure projects spread over several years, making capacity building in project appraisal, selection and procurement a long-term task. Investment projects' cash flows also follow different paths - e.g., are concentrated in the early years of construction – and are subject to risks – e.g., exchange rate fluctuations – that are not as common for current expenditures.

**The analysis also suggests that some other institutions that may be important in LIDCs and in other countries.** These include *Alternative infrastructure financing*, *Medium-term budgeting, Maintenance*, and *Asset monitoring*. The PCA and the regression results does not provide a basis for assessing the relative importance of these institutions across all LIDC PIMAs. However, this should not be interpreted to mean that the additional institutions are not important. For some LIDCs, they may be critical. The inconclusive results regarding the importance of *Alternative infrastructure financing*, may also be related to differences between LIDCs in whether public investment data includes public corporation investments.

**The specific policies and measures to realize improvements in key PIM institutions are discussed in a separate How-to-Note**.[19] This includes the five institutions identified as systematically important for public investment efficiency estimates in this paper, as well as some of the other institutions discussed in the analysis.

[19] How to improve PIM in LIDCs, HTN 24/xx, IMF, 2024.

# Annex I. Regression Results

**Multiple linear regressions were used to test if PIMA-PC* variables significantly predicted the efficiency and output indicators for public investment.** Tables 5 and 6 show the results for the priority PIM institutions in scenario 1, which followed from the PCA of the LIDC data set.

**Table 5: Regression results – investment efficiency indicators* - Scenario 1**

| | Hybrid Efficiency | | Physical Efficiency | | Quality Efficiency | |
|---|---|---|---|---|---|---|
| *Coefficient* | *Estimates* | *Conf. Int* | *Estimates* | *Conf. Int* | *Estimates* | *Conf. Int* |
| (Intercept) | 0.57*** | 0.48 – 0.65 | 0.49*** | 0.41 – 0.58 | 0.75*** | 0.71 – 0.80 |
| PIMA-PC1* | 0.10*** | 0.04 – 0.15 | 0.02 | -0.04 – 0.07 | 0.02 | -0.01 – 0.05 |
| PIMA-PC2* | -0.03 | -0.10 – 0.04 | 0.04 | -0.04 – 0.12 | -0.04* | -0.08 - -0.00 |
| PIMA-PC3* | -0.01 | -0.09 – 0.01 | 0.07 | -0.02 – 0.06 | -0.04 | -0.09 – 0.00 |
| Observations | 25 | | 30 | | 28 | |
| $R^2$ | 0.32 | | 0.10 | | 0.26 | |

Note: Confidence interval is 90%.
Source: Staff estimates, IMF Template of Investment and Efficiency (2022), IMF PIMA database.

Table 5 indicates that PC1* has a statistically significant impact on hybrid efficiency (99 percent confidence). PC2* has a significant impact on quality efficiency (90 percent). R2 for hybrid efficiency is quite high, at 0.32.

- PC1* is related to all 7 selected institutions: the main 5 (4, 14, 12, 11, 10), and 5 and 15. Within which 5 and 15 have the lowest loadings (0.34 and 0.28). The main 5 have loadings from 0.38 to 0.43.
- PC2* is mainly related to institutions 15, 10 and 12. Institution 15 has the highest loading within PC2* (0.78). Given that PC2* has a significant impact on quality efficiency, we consider that institution 15 is correlated to the quality efficiency in LIDCs.
- PC3* is mainly related to institutions 5, 4 and 14. Institution 5 has the highest loading within PC3* (0.85). However, given that coefficients of PC3* are not significant in the above regressions, and institution 5's loading is among the lowest within PC1*, we do not have strong evidence that institution 5 is significantly correlated to the investment efficiency in LIDCs.

**Table 6: Regression results – investment output indicators – Scenario 1**

| | Hybrid Output | | Physical Output | | Quality Output | |
|---|---|---|---|---|---|---|
| *Coefficient* | *Estimates* | *Conf. Int* | *Estimates* | *Conf. Int* | *Estimates* | *Conf. Int* |
| (Intercept) | 24.68*** | 20.65 – 28.72 | 25.37*** | 19.73 – 31.02 | 55.52*** | 52.75 – 58.23 |
| PIMA-PC1* | 5.14*** | 2.62 – 7.65 | 2.97 | -0.39 – 6.33 | 4.62*** | 2.80 – 6.44 |
| PIMA-PC2* | 0.74 | -2.49 – 4.04 | 5.81* | 0.76 – 10.86 | -2.31 | -4.63 – 0.01 |

| | | | | | | |
|---|---|---|---|---|---|---|
| PIMA-PC3* | 5.71** | 1.87 – 9.56 | 11.04*** | 5.53 – 16.54 | 2.69 | -0.05 – 5.43 |
| Observations | 25 | | 30 | | 28 | |
| $R^2$ | 0.42 | | 0.41 | | 0.46 | |

Note: Confidence interval is 90%.

Source: Staff estimates, IMF Template of Investment and Efficiency (2022), IMF PIMA database.

Table 6 indicates that the regression results against investment outputs have higher statistical significance than the regressions against efficiency. PC1* has statistically significant impacts on hybrid and quality output (99 percent confidence), while PC2* has significant impact on physical output (90 percent confidence). PC3* has significant impacts on hybrid output (95 percent confidence) and physical output (99 percent confidence).

- PC1* is related to all 7 selected institutions: the main 5 (4, 14, 12, 11, 10), and 5 and 15. Within which 5 and 15 have the lowest loadings (0.34 and 0.28). The main 5 have loadings from 0.38 to 0.43.
- PC2* is related to institutions 15, 10 and 12. Institution 15 has the highest loading within PC2* (0.78). Given that PC2* has significant impact on physical output, we consider that institution 15 is correlated to the physical output index in LIDCs.
- PC3* is related to institutions 5, 4 and 14. Institution 5 has the highest loading within PC3* (0.85). Given that PC3* has significant impact on hybrid and physical output, we consider that institution 5 is correlated to the hybrid and physical output index in LIDCs.

### Table 7: Regression results – investment efficiency indicators* - Scenario 2

| | Hybrid Efficiency | | Physical Efficiency | | Quality Efficiency | |
|---|---|---|---|---|---|---|
| *Coefficient* | *Estimates* | *Conf. Int* | *Estimates* | *Conf. Int* | *Estimates* | *Conf. Int* |
| (Intercept) | 0.64*** | 0.58 – 0.70 | 0.63*** | 0.57 – 0.69 | 0.72*** | 0.68 – 0.75 |
| PIMA-PC1* | -0.04*** | -0.06 – -0.02 | -0.01 | -0.04 – 0.01 | -0.02** | -0.03 – -0.00 |
| PIMA-PC2* | -0.00 | -0.05 – 0.04 | 0.06** | 0.02 – 0.1 | -0.02 | -0.05 – 0.01 |
| PIMA-PC3* | 0.03 | -0.03 – 0.08 | 0.04 | -0.01 – 0.09 | 0.00 | -0.03 – 0.03 |
| LIDC *(LIDC = 1, Others = 0)* | -0.02 | -0.12 – 0.08 | -0.11* | -0.21 – -0.02 | 0.05 | -0.01 – 0.12 |
| Observations | 62 | | 69 | | 68 | |
| $R^2$ | 0.15 | | 0.19 | | 0.09 | |

Note: Confidence interval is 90%.
Source: Staff estimates, IMF Template of Investment and Efficiency (2022), IMF PIMA database.

**Table 7 shows the regression results for scenario 2, based on scores for 82 PIMAs for all country groups.** The table indicates that PC1* has a statistically significant impact on hybrid efficiency (99 percent confidence) and quality efficiency (95 percent confidence). PC2* has a significant impact on physical efficiency (95 percent). The LIDC indicator variable has limited impact on efficiency, only 90 percent significance for physical efficiency. This implies that the differences in efficiency are largely related to the specific PIM institutions, rather than to the fact that the country is an LIDC in itself. While the regressions for this scenario show somewhat higher significance than the regressions for scenario 1, R2 for hybrid efficiency is significantly lower than for scenario 1.

- PC1* is related to all 9 selected institutions: the main 5, and 13, 5, 3, 9. Loadings[20] of institutions 13 5, 3 and 9 rank as the lowest within PC1*, range from 0.28 to 0.31. And loadings of the main 5 range from 0.32 to 0.39.

- PC2* is mainly related to institutions 10, 9, 13, 4, and 5. Among which institutions 10 and 9 have highest loadings as 0.62 and 0.48 (absolute values), respectively. PC2* has a significant impact on physical efficiency, we consider that institutions 10 and 9 are correlated to the physical efficiency.

- PC3* is mainly related to institutions 3, 13, 14, 5, and 12. Among which institutions 3 and 13 have the highest loadings as 0.69 and 0.45 (absolute values), respectively. However, given that coefficients of PC3* are not significant in the above regressions, we do not have strong evidence that institutions 3 and 13 are significantly correlated to the investment efficiency.

**Table 8: Regression results – investment output indicators – Scenario 2**

| | **Hybrid Output** | | **Physical Output** | | **Quality Output** | |
|---|---|---|---|---|---|---|
| *Coefficient* | *Estimates* | *Conf. Int* | *Estimates* | *Conf. Int* | *Estimates* | *Conf. Int* |
| (Intercept) | 53.32*** | 49.41 – 57.22 | 63.52*** | 58.26 – 68.78 | 67.46*** | 64.32 – 70.61 |
| PIMA-PC1* | -4.80*** | -5.97 – -3.04 | -3.79*** | -5.75 – -1.84 | -3.21 | -4.36 – -2.06 |
| PIMA-PC2* | 4.68*** | 1.93 – 7.66 | 8.30*** | 4.40 – 12.19 | 1.18 | -1.15 – 3.5 |
| PIMA-PC3* | 1.02 | -2.31 – 4.35 | 3.90 | -0.51 – 8.31 | -0.26 | -2.95 – 2.42 |
| LIDC *(LIDC = 1, Others = 0)* | -24.16*** | -30.39 – -17.94 | -33.54*** | -41.84 – -25.24 | -9.20*** | -14.18 – -4.22 |
| Observations | 62 | | 69 | | 68 | |
| $R^2$ | 0.66 | | 0.59 | | 0.38 | |

Note: Confidence interval is 90%.
Source: Staff estimates, IMF Template of Investment and Efficiency (2022), IMF PIMA database.

Table 8 indicates that the regression results against investment outputs have higher statistical significance also for this scenario. PC1* has statistically significant impacts on all three output categories (99 percent confidence), while PC2* has significant impact on both hybrid and physical output (99 percent confidence). In addition, the LIDC indicator variable has strong and significant impacts on all three output indicators, illustrating the systematically lower level of investment outputs in LIDCs.

- PC1* is related to all 9 selected institutions: the main 5, and 13, 5, 3, 9. Loadings of institutions 13 5, 3 and 9 rank as the lowest within PC1*, range from 0.28 to 0.31. And loadings of the main 5 range from 0.32 to 0.39.

[20] The loadings are all in absolute values.

- PC2* is mainly related to institutions 10, 9, 13, 4, 5. Among which institutions 10 and 9 have highest loadings as 0.62 and 0.48, respectively. Given that PC2* has significant impact on both hybrid and physical output, we consider that institutions 10 and 9 are correlated to hybrid and physical output index.

- PC3* is mainly related to institutions 3, 13, 14, 5, and 12. Among which institutions 3 and 13 have the highest loadings as 0.69 and 0.45, respectively. However, given that coefficients of PC3* are not significant in the above regressions, we do not have strong evidence that institutions 3 and 13 are significantly correlated to the output indexes.

Tables 9 and 10 show the regression results for scenario 3, where two institutions in PC1* in scenario 2 were replaced by others based on PIMA experience and judgement. The regressions results are very similar to the results for scenario 2. This implies that the exchange of PIMA institutions with lesser weight in the PCA has little impact on public investment effectiveness. So the results cannot be used to identify which of the institutions that differ between Scenarios 2 and 3 are most impactful.

**Table 9: Regression results – investment efficiency indicators* - Scenario 3**

| | Hybrid Efficiency | | Physical Efficiency | | Quality Efficiency | |
|---|---|---|---|---|---|---|
| *Coefficient* | *Estimates* | *Conf. Int* | *Estimates* | *Conf. Int* | *Estimates* | *Conf. Int* |
| (Intercept) | 0.64*** | 0.58 – 0.70 | 0.63*** | 0.57 – 0.69 | 0.72*** | 0.68 – 0.76 |
| PIMA-PC1* | -0.04*** | -0.07 – -0.02 | -0.02 | -0.04 – 0.01 | -0.02* | -0.03 – 0.00 |
| PIMA-PC2* | 0.01 | -0.04 – 0.05 | 0.03 | -0.02 – 0.07 | -0.01 | -0.04 – 0.02 |
| PIMA-PC3* | 0.00 | -0.05 – 0.05 | 0.06** | 0.01 – 0.11 | -0.01 | -0.04 – 0.02 |
| LIDC *(LIDC = 1, Others = 0)* | -0.03 | -0.12 – 0.07 | -0.12 ** | -0.21 – -0.03 | 0.05 | -0.02 – 0.12 |
| Observations | | 62 | | 69 | | 68 |
| $R^2$ | | 0.15 | | 0.19 | | 0.08 |

Note: Confidence interval is 90%.
Source: Staff estimates, IMF Template of Investment and Efficiency (2022), IMF PIMA database.

- PC1* is related to all 7 institutions: the main 5 (institutions 14, 4, 11, 12, 10), and 9 and 6. Within which institutions 9 and 6 have the lowest loadings (0.31 and 0.28). Loadings of the main 5 range from 0.38 to 0.44.

- PC2* is mainly related to institutions 6, 4 and 10. Among which institution 6 has the highest loading as 0.70. However, given that coefficients of PC2* are not significant in the above regressions.

- PC3* is mainly related to institutions 9, 6 and 10. Among which institutions 9 and 6 have the highest loadings as 0.76 and 0.50, respectively. Given that PC3* has significant impact on physical efficiency, we consider institutions 9 and 6 to be correlated with the physical efficiency.

### Table 10: Regression results – investment output indicators – Scenario 3

| | Hybrid Output | | Physical Output | | Quality Output | |
|---|---|---|---|---|---|---|
| *Coefficient* | *Estimates* | *Conf. Int* | *Estimates* | *Conf. Int* | *Estimates* | *Conf. Int* |
| (Intercept) | 53.66*** | 49.72 – 57.59 | 63.52*** | 58.03 – 69.00 | 67.82*** | 64.70 – 70.94 |
| PIMA-PC1* | -4.83*** | -6.42 – -3.24 | -4.13*** | -6.34 – -1.93 | -3.33*** | -4.57 – -2.01 |
| PIMA-PC2* | 4.60** | 1.67 – 7.51 | 3.79 | -0.32 – 7.90 | 2.85* | 0.47 – 5.22 |
| PIMA-PC3* | 2.20 | -0.84 – 5.24 | 6.56** | 2.26 – 10.85 | -0.93 | -3.33 – 1.48 |
| LIDC *(LIDC = 1, Others = 0)* | -25.53*** | -31.278 – -19.29 | -34.97*** | -43.485 – -26.45 | -10.36*** | -15.30 – -5.41 |
| Observations | 62 | | 69 | | 68 | |
| $R^2$ | 0.66 | | 0.58 | | 0.44 | |

Note: Confidence interval is 90%.
Source: Staff estimates, IMF Template of Investment and Efficiency (2022), IMF PIMA database.

- PC1* is related to all 7 institutions: the main 5 (institutions 14, 4, 11, 12, 10), and 9 and 6. Within which institutions 9 and 6 have the lowest loadings (0.31 and 0.28). Loadings of the main 5 range from 0.38 to 0.44.

- PC2* is mainly related to institutions 6, 4 and 10. Among which institution 6 has the highest loading as 0.70. Given that PC2* has significant impact on hybrid and quality output, we consider institution 6 to be correlated to the hybrid and quality output indexes.

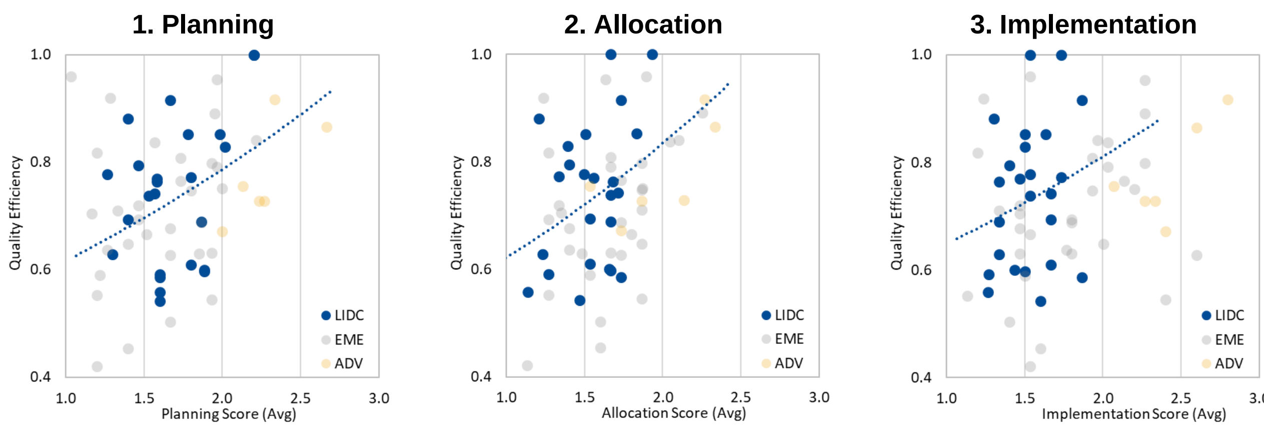
- PC3* is mainly related to institutions 9, 6 and 10. Among which institutions 9 and 6 have the highest loadings as 0.76 and 0.50, respectively. Given that PC3* has significant impact on physical output, we consider institutions 9 and 6 to be correlated with the physical output index.

# Annex II. Correlation between PIM capacity and quality efficiency

Figure 8 presents the same graphs as Figure 7, but excluding 5 countries that could be outliers, that is, countries that were identified to have a very high efficiency score (close to or equal to 1) but very weak PIMA rating (slightly above 1) or low efficiency (less than 0.6) with a strong rating (two or above).

Excluding the outliers, Figure 8 shows a clear positive correlation between countries' average scores for each PIMA pillar (horizontal axis – 3 implies high score) and the estimated quality efficiency level (vertical axis – 1 implies no efficiency gap). We see that countries with higher PIMA scores generally are much closer to the efficiency frontier.[21]

**Figure 8: Correlation between PIM capacity and quality efficiency**




Source: IMF PIMA database, IMF Template of Investment and Efficiency (2022).
Note: Trendline is only for LIDCs

**The graphical representations illustrate two key points regarding the correlations between PIM effectiveness and quality efficiency.**

- The trendlines for LIDCs confirm a positive relationship between PIM and quality investment efficiency across all three phases. The strongest correlation appears to be for the allocation phase, during which budgeting of public investments and maintenance expenditure are assessed.
- The correlation between PIM and investment efficiency is weakest in the implementation phase, but still clearly positive. This differs from the result in figure 7, where the five potential outliers were included in the data set.

[21] Quality efficiency refers to the relationship between public capital stock and perceived quality of infrastructure.

# References

IMF, 2016, IMF Public Expenditure and Financial Accountability Framework.

IMF, 2018, *Public Investment Management Assessment — Review and Update*.

IMF, 2019, IMF Investment and Capital Stock Dataset.

IMF, 2022, IMF Template of Investment & Efficiency.

Jolliffe and Cadima, 2016, *Principal component analysis: a review and recent developments*. Philos Trans A Math Phys Eng Sci. 2016 Apr 13; 374(2065): 20150202. doi: 10.1098/rsta.2015.0202. PMID: 26953178; PMCID: PMC4792409.

Kapsoli, Mogues, Verdier, 2023, *Benchmarking Infrastructure Using Public Investment Efficiency Frontiers.* IMF Working Paper, WP/23/101.

Schwartz, Fouad, Hansen and Verdier, 2020, *Well Spent: How Strong Infrastructure Governance Can End Waste in Public Investment*. IMF Books.

Tandberg, Eltokhy, Feruglio, Navarro and Miao, 2024, *How to improve PIM in LIDCs*, IMF How To Note, HTN/24/xx.

PUBLICATIONS