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THE DETERMINANTS OF PRIVATE INVESTMENT IN A MINING EXPORT ECONOMY. PERU: 1997-2017

Waldo Mendoza Bellido y
Erika Collantes Goicochea

DEPARTAMENTO DE ECONOMÍA

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THE DETERMINANTS OF PRIVATE INVESTMENT IN A MINING EXPORT ECONOMY.
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RESUMEN

El Perú es una economía donde alrededor del 60 por ciento de las exportaciones son de minerales y la mitad de estas son de cobre. ¿Cuál es el peso de los factores internacionales y los factores domésticos en la determinación de la inversión privada en esta economía minero exportadora?

En este trabajo se ha encontrado la influencia dominante de las condiciones internacionales en la evolución de la inversión privada en el Perú y el enorme peso individual del precio de las exportaciones en dicha evolución. En el periodo 1997-2017, los factores externos han explicado el 54, el 64 y el 38 por ciento de la varianza de la tasa de crecimiento de la inversión privada total, de la inversión minera y de la inversión no minera, respectivamente; y aproximadamente más de la mitad del peso de los factores externos ha estado explicada por el precio de las exportaciones. Por otro lado, los factores internos han explicado el 46, el 36 y el 62 por ciento de la varianza de la tasa de crecimiento de la inversión privada total, de la inversión minera y de la inversión no minera; y alrededor del 40 por ciento del peso de los factores domésticos ha estado explicado por la inversión pública.

Estos hallazgos son importantes pues identifican al precio de las exportaciones como el principal canal que conecta la inversión privada en el Perú con la economía mundial, y a la inversión pública como la variable de política más eficaz para afectarla.

Palabras clave: Inversión privada total, inversión privada minera, inversión privada no minera, precio de exportaciones, inversión pública, fluctuaciones, impulso-respuesta, descomposición de la varianza, descomposición histórica.
Códigos JEL: C32, E22, E32, H54, L72, L74.

ABSTRACT

Peru is an economy where about 60 percent of exports are mineral, of which copper, in turn, represents half. What is the weight of international factors and domestic factors in determining private investment in this mining export economy?

In this paper, we identify the dominant influence of international conditions on the evolution of private investment in Peru, as well as the enormous individual weight of the price of exports in this evolution. In the period 1997-2017, external factors explained 54, 64 and 38 percent of the variance in the growth rate of total private investment, mining investment, and non-mining investment, respectively; while more than, half of the weight of external factors was explained by the price of exports. On the other hand, domestic factors explained 46, 36 and 62 percent of the variance in the growth rate of total private investment, mining investment and non-mining investment; while about 40 percent of the weight of domestic factors was explained by public investment.

These findings are important because they show the price of exports to be the main channel connecting private investment in Peru with the world economy, and public investment as the most effective policy variable affecting it.

Keywords: Total private investment, private mining investment, non-mining private investment, export price, public investment, fluctuations, impulse-response, variance decomposition, historical decomposition.
JEL Codes: C32, E22, E32, H54, L72, L74.

THE DETERMINANTS OF PRIVATE INVESTMENT IN A MINING EXPORT ECONOMY. PERU: 1997-2017[1]

Waldo Mendoza Bellido and Erika Collantes Goicochea

INTRODUCTION

Peru is a mining export economy. Around 60 percent of all its exports are minerals, of which half, in turn, is copper. What are the determinants of private investment in an economy of this type? Moreover, what weight do international and domestic factors have in its determination?

The main objective of this paper is to answer these two questions. Our working hypothesis is that private investment in Peru depends fundamentally on international factors, and that the main transmission channel of this dependence is the global price of Peru's exports.

We test this hypothesis by way of the structural vector autoregressions (SVAR) method, using a long-term decomposition in order to obtain the impulse-response functions, the decomposition of variance in private investment, and the historical decomposition of annual private investment, discriminating between foreign and domestic determinants.

Our study develops the existing literature in three ways. First, a theoretical model that sorts private investment into mining and non-mining supports our SVAR model explicitly. Second, in view of the above, we will obtain results not only for the determinants of total private investment, but also for disaggregated private investment. Third, our period of study, 1997:Q1 - 2017:Q4, is more extensive than those of preceding works.

This paper is organized as follows. In the first section, we present a review of the theoretical and empirical literature on the determinants of private investment. In the second section,

[1] Professor and Teaching Assistant, respectively, of the Department of Economics, Pontificia Universidad Católica del Perú (PUCP). This study has been financed by funds from the PUCP's Vice Rectorate for Research as part of the 2017 Annual Research Grant. The authors thank Gabriel Rodríguez, Carlos Montoro, Fernando Vasquez, and Karl Melgarejo for their comments on a preliminary version of this paper. Any errors that remain are ours.

we present the literature that focuses on the Peruvian economy. In the third section, we present a theoretical model that includes two types of investment: mining investment, linked to the international market; and housing or non-mining investment, linked to the domestic market. In the fourth section, we present the stylized facts about the relationship between total mining investment, private mining and non-mining investment, and their main determinants. In the fifth section, we quantify the importance of foreign and domestic factors in determining total private investment, private mining investment, and private non-mining investment for the period 1997-2017. Finally, in the sixth section we present our conclusions and the economic policy implications.

1. DETERMINANTS OF PRIVATE INVESTMENT: LITERATURE REVIEW

The theories on investment in physical capital have undergone significant development over time. A comprehensive account of these developments can be found in Baddeley (2003).

The works of Jorgenson (1963), Hall & Jorgenson (1967), Tobin (1969), Bernanke (1983), and Pindyck (1991) are the primary references for understanding the theory around the determinants of private investment.

The neoclassical model of Jorgenson (1963) establishes that the firm accumulates the optimal capital stock by maximizing profits period after period. From this optimization process, it can be discerned that private investment is a direct function of expected economic activity and an inverse function of the user cost of capital. This model, combined with that of the flexible accelerator, in which investment depends dynamically on the level of economic activity, result in the neoclassical flexible model of Hall & Jorgenson (1967).

An important extension of the neoclassical investment demand model is the consideration, by Bernanke (1983) and Pindyck (1991), of uncertainty as an additional determinant of investment, especially given the economically irreversible nature of fixed capital investment decisions, in that there are sunk costs that cannot be recovered.

None of these are complete theories, in terms of taking into account the largest possible set of determinants. Tobin (1969) took an important step. His model links investment with the stock exchange. The firm invests if its Q ratio, its market value divided by its replacement cost, is greater than the unit is. Since the firm's stock value is expressed in the market value of a share, and this is equal to the current value of the expected future dividends to be distributed among shareholders, this variable captures the influence of a near-infinite set of determinants. In this sense, investment demand based on Tobin's Q, in theory, is more complete. The Q coefficient may constitute sufficient information for an investment decision.

The most-recent advances —microfunded, stochastic, and dynamic models with better econometric procedures and detailed panel databases— are developments of the models presented. On this, see Romer (2012).

In sum, existing theories about private investment predict that it will be low when the expected return, or Tobin's Q, are low; or when the cost of financing, the variance of the return, or the risk aversion are high.

The major problem with these models is that they were intended for closed economies, and there is a paucity of theoretical models about the determinants of private investment in open economies. Thus, in the theoretical sphere, it would seem pertinent to adapt some of the abovementioned models to the characteristics of Peru: a small, open mining exporter.

In the empirical domain there have been a number of works, especially those of the International Monetary Fund (IMF) that prove highly useful for approximating the Peruvian case.

In IMF (2015a) and, thereafter, more expansively, in Magud & Sosa (2015), attempts are made to answer the question of what factors determine investment in emerging countries. In the latter study, panel regressions with firm-level data are used, replicating the methodology of IMF (2014b) but with the addition of three explanatory variables of the international context: commodity export prices, net capital inflows, and global uncertainty.

The study draws on information about 16,000 listed firms from 38 emerging countries, Peru among them, over the period 1990-2013.

The results at firm level are very similar to those obtained in IMF (2014b). What is novel in this latter case is that commodity prices and capital inflows are statistically very significant in explaining private investment, but international uncertainty is not.

In the same study, simple macroeconomic panel regressions are performed, with country and time fixed effects, on quarterly data for 30 emerging economies corresponding to the period 1990-2014. An expanded model of the flexible accelerator is employed. The explanatory variables are commodity export prices, global uncertainty, real lending rates, GDP growth, and net capital inflow as a percentage of GDP. All variables are statistically significant, and the results illustrate the significant role of commodity export prices and capital inflows as factors determining investment in emerging economies.

The study also contains an exercise to identify which of these factors contributed most to Latin America's investment slowdown over the period 2011-2014. The contribution of each of the factors to the slowdown is calculated by multiplying the accumulated variation of each variable since 2011 by its estimated marginal effect on each region's regression. Sizable contributions are made by the size of the shocks and the coefficients estimated. In the exercise, the decline in the commodity export price proves to be the factor that has contributed most to the cool-off in private investment in Latin America during the period in question.

Finally, in the same work, as a complement to these exercises, vector autoregressive (VAR) models are estimated for three Latin American countries: Brazil, Chile, and Peru. Each VAR includes variables corresponding to the international context (commodity prices, world economic growth, and world financial volatility) as well as domestic variables (Tobin's Q, real exchange rate, and increase in investment and real GDP). It is surprising that public investment has not been included among the domestic variables.

The most important finding, based on a historical decomposition of investment growth, is that the most important determinant of the investment slowdown in Brazil, Chile, and Peru over the period 2011-2013 was the lower price of commodity exports. However, the exact magnitude of this contribution is not stated.

For the Peruvian economy, the historical decomposition of investment shows not only that lower commodity export prices have been important determinants in the slowdown, but also that expectations of lower profitability (measured by Tobin's Q) have, by comparison, been less relevant to the behavior of investment throughout the sample.

2. DETERMINANTS OF PRIVATE INVESTMENT IN PERU: WHAT DO WE KNOW?

The literature on the determinants of private investment in Peru is extensive.

Gonzales (1996), with annual information for the period 1950-1993 and utilizing an ordinary least squares (OLS) method, finds that there have been three primary and two secondary determinants of private investment in Peru. The primary determinants in the long run are the economic cycle or the level of economic activity, domestic credit, and the political cycle. The secondary determinants are profits, public investment, and investors' expectations.

Castillo & Salas (2010) present an empirical analysis of the relationship between terms-of-trade shocks and output fluctuations, consumption, and investment for Peru during the period 1992-2007, at a quarterly frequency. The authors employ a VAR model with common stochastic trends, based on King et al. (1991) and Mellander et al. (1992). For the case of investment, they find that permanent terms-of-trade shocks constitute the most important explanation of investment fluctuation, and that these shocks are quantitatively more relevant as drivers of fluctuation in the medium and long run.

Rodríguez & Villanueva (2014) extend the proposal of Castillo & Salas (2010), conducting an analysis that disaggregates total public and private investment for the same period of study. Their main result is that permanent shocks in the terms of trade (external shocks) explain most of the fluctuations in private and public investment. This result becomes more pronounced with proximity to the long-term horizon. The authors conclude that high private-investment growth in an emerging country such as Peru, in the context of a small open economy, is closely linked to external factors such as commodity price increases. In addition, they analyze the historical decomposition of private investment, for the periods 1994-2000 and 2001-2007, as another way of measuring the relative importance of external factors versus domestic factors in the development of each variable. The results also reveal the extent to which private investment in the Peruvian economy is sensitive to external factors.

Mendiburu (2010) finds a positive relationship between investment cycles and terms-of-trade fluctuations around its trend in the period running from the first quarter of 1993 to the third quarter of 2009. The maximum correlation between investment fluctuation and the cyclical component of the terms of trade occurs with a two-quarter lag. This means that variations in the terms of trade precede investment changes during this period of the sample.

The central aim of Montoro & Navarro (2010) is to estimate Tobin's Q for the Peruvian economy, and determine its influence on private investment. To calculate Tobin's Q, they use the listings and financial statements of 49 firms, available in Economatica, for the period 1999:Q1 - 2009:Q1. Then, they estimate an investment function, whose explanatory variables are lagged investment, Tobin's Q, and the terms of trade. They utilize the generalized method of moments given the expectation of endogenous relationships between the variables. The authors find a good correlation between the Tobin's Q estimated and investment, and that the Q can be a leading indicator of investment.

Moreover, while the focus of their study is Tobin's Q, the authors observe that the terms of trade variable is the most important in explaining investment. This result is obtained even though the study does not explore the heavy dependence that ought to exist in a country such as Peru between the stock exchange index and mining shares. That is, the influence of the commodities price, or the terms of trade, should be much greater than that reported by the authors.

Arenas & Morales (2013) do not seek to identify the determinants of private investment, but to find a leading indicator for this variable. Using information from the period 2003:Q2 -

2011:Q4, they aim to answer the question: Are the business confidence indices issued by the Central Reserve Bank of Peru (BCRP) useful in forecasting the behavior of private investment in Peru?

The authors find that the answer to this question is affirmative. They also show that the model estimated with this expectations variable alone is a better predictor than others with control variables such as GDP growth, inflation, or the interest rate.

Using the Granger causality test as their econometric method, the authors observe that this index causes annual changes in private investment, and thus assert that these variables may be potential candidates for explaining the behavior of real private investment. Moreover, they employ linear and non-linear presentations[2] to determine which has the best predictive power of private investment. The non-linear models are based on the notion that the determinants of private investment can affect it in different ways over time; specifically, in this study a threshold autoregressive (TAR) model is employed. They find that non-linear models are no better than linear-models at predicting the evolution of private investment growth in Peru.

The authors do not include variables of the international context in their exercises. We suspect that this omission overestimates the influence of business confidence as a leading indicator of private investment. Ross & Tashu (2015), who detect a strong correlation between commodities price and the same business confidence index, as that used by Arenas y Morales (2013), support our expectation. We will return to this topic later.

Meanwhile, Fornero, Kirchner & Yany (2016) study the effects of commodities prices in small open export economies, of which Peru is one, using a SVAR model with an exogenous block. The sample covers a period from 1998:Q1 to 2013:Q4, and considers one external block and another external one. The external block includes a measure of global GDP, foreign inflation and interest rates, and a real commodities price. In turn, the internal block takes into

2 These models take private investment as an endogenous variable; and an inertial component of private investment, the BCRP business confidence index, the local currency interest rate for the previous period, and GDP growth for the previous period as explanatory variables.

account inflation, the domestic interest rate, real exchange rate, current account balance, and mining and non-mining investment.

The results show that given a commodities price shock, Peruvian mining investment tends to react to a limited degree during the period of impact, but that after three quarters the impact is positive and major, albeit less persistent in comparison with other countries in the sample (Australia, Canada, Chile, and South Africa). On the other hand, the effects on non-mining investment only become significant from the eighth quarter onwards, and the effects are likewise not persistent. This work makes no mention of the exact magnitude of this impulse-response, limiting itself to showing the results graphically.

In addition, the study provides a historical decomposition of growth in investment for the Chilean economy alone, for the period 2001:Q3 - 2013:Q4. The results show that most above-average investment growth in Chile between 2004 and 2010 can be explained by commodities prices, while other external factors (such as foreign interest rate, global GDP, or foreign inflation) have a minor importance. As such, these results suggest that commodities price fluctuations have been a significant driving force behind the investment cycle in Chile over the last decade.

The BCRP (2014), utilizing a regression with annual data from 1950 to 2013, estimates that an increase by one percentage point in the terms-of-trade growth rate in a given year will hasten growth in private investment by 0.5 percentage points in that same year. When data of greater frequency is used, the positive relationship between private investment and terms of trade remains. Then, using a VAR method with quarterly growth rates for terms of trade, GDP, investment, and consumption, they provide a historical decomposition of investment to determine the importance of term of trade in its evolution.

The results show that the terms of trade have contributed positively to the evolution in investment, particularly prior to 2008, when they accounted for almost three percentage points of its growth; while in 2009, when the terms of trade fell significantly, the contribution was strongly negative. For 2013, this estimation suggests that the contribution of the terms of trade to investment was 1.1 percentage points. Finally, the study concludes that in the face of a ten percentage-point reduction in terms of trade, investment would contract by between five and eight percentage points.

On the other hand, BCRP (2016) seeks to assess the effects that changes in business confidence have on private investment by estimating a SVAR system that includes an external block containing a cyclical component of the terms of trade; and an internal block that includes the cyclical component of general government spending, private investment, GDP, and the business expectations index. The estimation was conducted using quarterly information between 2002 and 2016.

The variance decomposition of private investment shows that the terms of trade account for 34 percent of the fluctuation in this variable. Of the internal factors, an estimated 44 percent of investment variability is explained by idiosyncratic shocks associated with longer-term investment decisions; 18 percent is due to business confidence shocks and improved perception of the business climate; and four percent owes to exogenous shocks in public spending.

Finally, another important work is that of IMF (2015b), expanded in Ross & Tashu (2015). These studies contain a descriptive section that stresses the role of international prices, their effect on mining investment, and the effect of this investment on mining activity in Peru.
These descriptions set out some stylized facts about investment in recent decades. First, the mining industry's need for capital equipment helped drive the investment boom. Second, public investment spending rose in line with private investment, reflecting investment promotion initiatives and the need to cover major infrastructure gaps. Third, long-term capital flows contributed to the rise in investment in Peru. Finally, the rise in the price of commodities and favorable external financing, both of which sustained the rise in private investment over the last decade, have gone into reverse.

Ross & Tashu's (2015) study is based on Jorgenson's (1963) neoclassical model, in which investment is positively related to the expected level of economic activity and negatively related to the expected cost of capital usage and uncertainty. Given the typical problem of endogeneity between investment and the expected level of economic activity, the authors include the probable determinants of this latter variable. Thus, they encompass variables such as the commodities price, structural reforms, and public investment in infrastructure and human capital. In a financially open economy, the international interest rate is that which represents the cost of capital.

In the empirical part of the study, covering the period 1984-2013, the authors use an error correction model and the results are in line with expectations. The most important explanatory variables are the commodities price and the political risk index, constructed based on the Political Risk Service Group (PRSG). A ten percent increase in the commodities price leads to a 4.8 percent rise in the investment-to-GDP ratio. On the other hand, a rise of ten percent in the political risk index leads to a 16.75 percent drop in the investment-to-GDP ratio. The importance of this variable, which is afforded little prominence in the other studies reviewed, is surprising.

In sum, the empirical evidence reveals that the terms of trade or export prices have played a very important role in explaining the behavior of private investment in Peru. In addition, in some works that include a measure of expectations, such as the business confidence index or Tobin's Q, it is found that this variable's contribution is very limited in comparison with the terms of trade or export prices when it comes to explaining the variability or fluctuation in private investment in Peru.

Our study will be in line with the variables used by Magud & Sosa (2015), but we will adapt the model to include public investment as one of the internal variables. Including public investment as one of the internal variables is of relevance, as there is evidence of a public investment complementarity effect for the Peruvian economy, just as Vtyurina & Leal (2016) suggest.

Unlike IMF (2015a) and Magud & Sosa (2015), a theoretical model that divides private investment into mining and non-mining supports our SVAR model; as such, we obtain results not only for total private investment, but for disaggregated investment as well. Our period of study, 1997:Q1 – 2017:Q4, is also longer, covering ten years more than the 2003:Q1 – 2013:Q3 of IMF (2015a) and Magud & Sosa (2015). Finally, rather than including Tobin's Q or return expectations in the domestic variables, we will include, where possible, the three-month economic expectations constructed by the BCRP.

3. THE THEORETICAL MODEL AND THE HYPOTHESIS[3]

This is a basic model intended to serve as a framework of analysis for understanding the determinants of private investment, and to formulate the variables to be utilized in the SVAR system in Section 5. It is assumed that there are two types of investment in this economy. One, investment in the mining sector, is linked to the external market; while the other, non-mining investment in the housing sector, is linked to the internal market.

In the model, the treatment of the two types of investment is asymmetric. Mining investment is dominant: it affects, but is not affected by, what occurs in the housing construction sector.

In the tradable sector of the economy, mining sector production is entirely bound for export at a price determined by international demand. Investment demand in this sector is derived from mining production, financed at the interest rate set by the international market. In the housing sector, the price and volume of investment are determined in the local market, by supply and demand.

3.1 Mining investment

We assume a small open economy in the goods markets and in the financial markets. In the goods market, mining production is wholly destined for export at a price given by the world market; and in the financial market, there is external financing for investment in this sector at the current international interest rate.

[3] Theoretical model can be found in Mendoza and Collantes (2018).

The mining export sector

Let us consider the following production function of a mining product, "processed ore" —an adaptation of chapter 7.2 of Sorensen and Whitta-Jacobsen (2008), drawing on the Solow model in the presence of a non-renewable production factor.

$$Y_t = HK_t^{\alpha}L_t^{\beta}M_t^{\gamma}; \alpha + \beta + \gamma = 1 \quad (1)$$

In this equation, Y_t is the volume of production of processed ore, H the complementary public infrastructure for mining activity[4], K_t the stock of capital necessary for the export of ore, L_t the labor employed in mining, and M_t is the non-renewable production factor, the "crude ore" used in the production process.

Given the presence of a non-renewable natural resource as a production factor, we must propose an equation that models the use and the period of depletion of that resource. Equation (2) establishes that at the beginning of the period, $t + 1$, the stock of crude ore (R_{t+1}) is equal to the stock existing in the previous period (R_t), less the part used in the production process during that period (M_t). That is,

$$R_{t+1} = R_t - M_t \quad (2)$$

If it is assumed that, a constant fraction δ of the existing crude ore reserves is used in each period, then,

$$M_t = \delta R_t; 0 < \delta < 1 \quad (3)$$

That is,

$$R_{t+1} = (1 - \delta)R_t \quad (4)$$

[4] In Jones (1997), chapter 7, it is shown how infrastructure, in its broadest expression, fosters the productivity of the production factors. In this model, we focus our attention on public infrastructure. From there, it is inferred that there is complementarity between public and private investment.

Given this rule of crude ore extraction, the growth rate of the quantity of resources is constant and equal to – δ. This means that the stock of this resource has its own dynamic. Based on an initial value of R_0, the stock of mineral resources evolves according to the following formula,

$$R_t = (1-\delta)^t R_0 \tag{5}$$

The mineral resource usage flow will therefore be given by,

$$M_t = \delta(1-\delta)^t R_0 \tag{6}$$

By replacing equation (6) in the production function (1), we arrive at the following expression with the determinants of processed ore production in this economy.

$$Y_t = HK_t^{\alpha} L_t^{\beta} [\delta(1-\delta)^t R_0]_t^{\gamma} \tag{7}$$

All of the processed ore produced is exported. Since the context is a small open economy, the product is sold at a price determined by international demand.

$$P_x^* = P_{x0}^* \tag{8}$$

Investment in the mining sector

The mining company's profit in dollars is given by the difference between the income from the sale of processed ore $(P_x^* Y)$ and the variable costs, which we limit to those arising from the capital, financed entirely by external loans at the international interest rate r^*. That is,

$$\Pi^Y = P_x^* Y - r^* K \tag{9}$$

A mining company that seeks to maximize its profits must select the ideal level of investment, such that the value of the marginal product of capital is equal to the international interest rate. That is,

$$P_x^* Y_k = r^* \tag{10}$$

In turn, the marginal product of capital is obtained from equation (1) and is given by,

$$Y_k = \frac{\alpha Y_0}{K} \qquad (11)$$

Where $Y_0 = HK_0^{\alpha} L_0^{\beta} M_0^{\gamma} = HK_0^{\alpha} L_0^{\beta} [\delta(1-\delta)^t R_0]_0^{\gamma}$ is mining production in the initial situation. Note that the extraction rule for the metal ore means that mining production tends to zero ($Y_0 \rightarrow 0$) as time tends to infinity ($t \rightarrow \infty$).

In consequence, the desired or optimal capital stock (K^o), that which maximizes the mining company's profits, is equal to,

$$K^o = \frac{P_x^* \alpha Y_0}{r^*} = \frac{P_x^* \alpha H K_0^{\alpha} L_0^{\beta} [\delta(1-\delta)^t R_0]_0^{\gamma}}{r^*} \qquad (12)$$

The capital stock desired by the company will be greater the higher the (initial) mining production or the world price of mining exports, and the lower the international interest rate. In turn, the initial production is a direct function of the available stock of mineral resources. If no new mineral resources are discovered, the stock of resources declines period after period as it is used in the production process, due to which the mining sector's demand for capital will also fall period after period.

On the other hand, investment cannot instantly increase to close the gap between the desired capital stock and the actual stock. There are adjustment costs that prevent this. A linear version of the flexible accelerator model, from the same family as Hall and Jorgenson's (1967) model, enables formulation of the speed at which companies adjust capital stock to the desired stock over time.

$$K_t = K_{t-1} + \varepsilon(K^o - K_{t-1})\,;\, 0 < \varepsilon < 1. \qquad (13)$$

In this equation, ε is a parameter of the speed of adjustment, which indicates the extent of the gap between optimal capital and existing capital ($K^o - K_{t-1}$) that the company seeks to close in a given period.

Consequently, investment in the mining industry (I^m) —that is, the change in the capital stock in that sector— is determined by the following equation,

$$I^m = K_t - K_{t-1} = \varepsilon(K^o - K_{t-1}) \quad (14)$$

By replacing (12) with (14), we arrive at the equation with the determinants of mining investment, from the demand point of view.

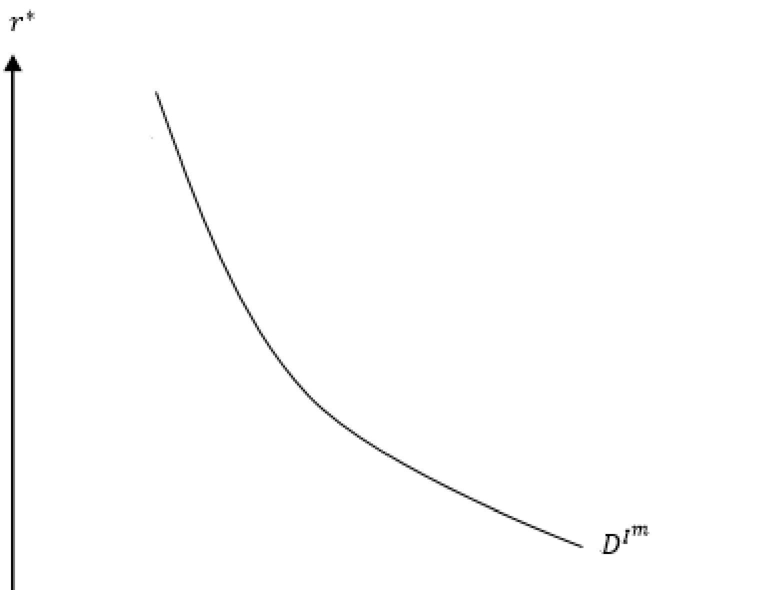
$$I^m = \varepsilon\left[\frac{P_x^* \alpha Y_0}{r^*} - K_{t-1}\right] \quad (15)$$

Reordering this equation, we arrive at equation (16), which is the mining-investment demand curve, represented by Figure 1.

$$r^* = \frac{\varepsilon P_x^* \alpha Y_0}{I^m + \varepsilon K_{t-1}} \quad (16)$$

Figure 1

Mining investment demand



As summarized in equation (17), the demand for investment in the mining sector is a direct function of the speed of adjustment of the sector's capital stock to its optimal level, the international price of mining exports, and the initial volume of mining production; and an inverse function of the international interest rate and the capital stock from the previous period. As we saw earlier, the initial mining production is a direct function of the available stock of mineral resources, which tends to depletion as it is used in the production process.

$$I^m = I^m(\varepsilon, P_x^*, Y_0, r^*, K_{t-1}) \tag{17}$$

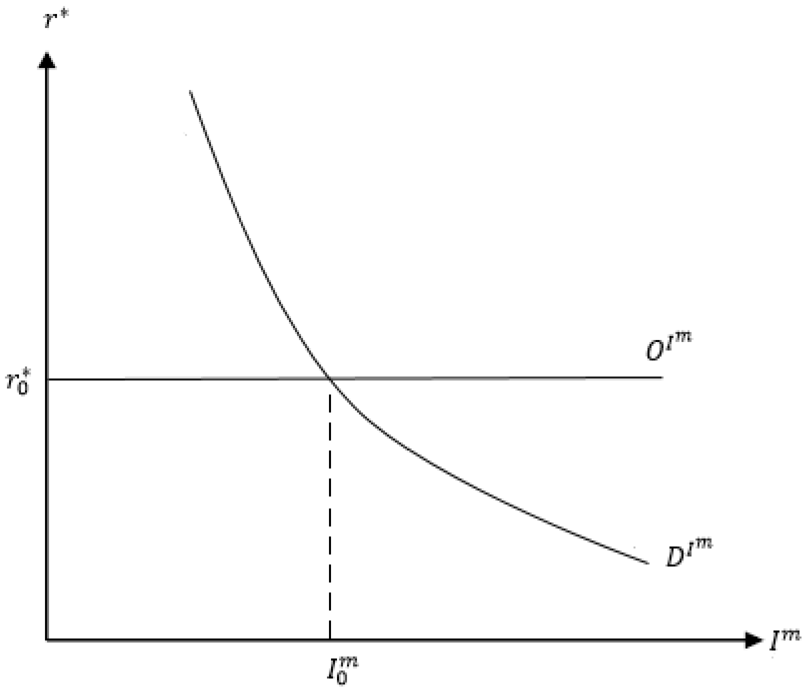
On the other hand, for this export sector, given the presence of free movement of financial capital, the supply of financing from investments is perfectly elastic to the international interest rate.

$$r^* = r_0^* \tag{18}$$

Thus, Figure 2 can represent the equilibrium in the mining investment market.

Figure 2

The mining investment market



3.2 Non-mining investment

We will approximate non-mining investment by way of investment in an important non-tradable sector in Peru, housing, based on a housing supply-and-demand model similar to that presented in chapter 2.4 of Sorensen & Whitta-Jacobsen (2009). See also chapter 5 of Mendoza (2018).

Housing supply

Let us consider the following production function of the housing construction firm.

$$I^V = AX^\beta;\ 0 < \beta < 1 \tag{19}$$

In this expression, I^V is a constructed housing unit, X is a compound production factor (labor and construction materials), A is a constant that represents public infrastructure (roads, motorways, other transportation routes) necessary for the construction of housing[5], and β expresses that the production of housing is subject to decreasing returns to scale. To obtain the compound input, companies combine labor and building materials in fixed proportions. Let us assume that the unit cost of the compound input is C^V.

If the price of the houses in local currency is P^V, the construction firm's profit (Π^V) will be equal to the difference between income from the sale of housing ($P^V I^V$) and the total costs of producing it ($C^V X$). Moreover, taking into account, based on (19), that $X = \left(\frac{I^V}{A}\right)^{1/\beta}$, we obtain the following expression

$$\Pi^V = P^V I^V - C^V X = P^V I^V - C^V \left(\frac{I^V}{A}\right)^{1/\beta} \tag{20}$$

A competitive construction firm will select the level of investment that allows it to maximize its profits. From equation (20), it is inferred that the construction firm maximizes profits

[5] We are also assuming here that that there is complementarity between public and private investment.

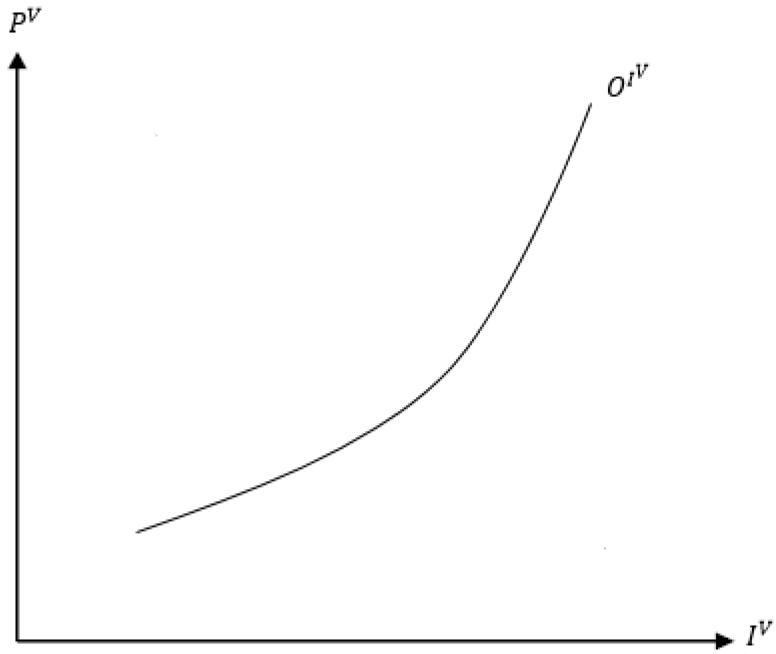
when the price of the housing, (P^V), equals the marginal cost of producing it ($\frac{\partial C^V X}{\partial I^V}$). That is, when,

$$P^V = \frac{C^V}{\beta A}\left[\frac{I^V}{A}\right]^{(1-\beta)/\beta} \quad (21)$$

This is, also, in perfect competition, the supply curve of the housing construction firm shown in Figure 3.

Figure 3

Housing investment supply



From this expression, by finding I^V, the function showing the determinants of investment in housing is obtained, from the supply side.

$$I^V = k\left[\frac{P^V}{C^V}\right]^{\beta/1-\beta}; k \equiv \beta^{\beta/(1-\beta)}A^{1/(1-\beta)} \quad (22)$$

Investment in construction is therefore a direct function of the relative price of houses in terms of the unit cost of production, and of the public infrastructure stock. Note that the relative price, $\frac{P^V}{C^V}$, which links the housing market price to the cost of production, is similar to Tobin's q which relates the market value or the stock-market value of a capital good with the production cost of that capital good. Our housing construction investment model therefore fits Tobin's q theory.

Housing demand

On the demand side, we will assume that there is a typical consumer with a utility function and a budget for purchasing non-durable consumer goods, for paying interest on a mortgage loan, and for the depreciation costs of the housing acquired with the mortgage. Part of consumer income is linked to mining activity[6].

The utility function of these families is of the Cobb-Douglas type, which depends on the housing trend (I^V)[7] and the consumption of non-durable goods (C).

$$U = (I^V)^n (C)^{1-n};\ 0 < n < 1 \tag{23}$$

To define the consumer's budget constraints, let us suppose there is a representative consumer who applies for a mortgage to acquire a quantity of housing I^V at the unit price P^V, and that in each period she spends a fraction of the total value of the housing to pay the mortgage interest (r) and to cover the housing depreciation costs, which is composed of the costs of maintenance and repairs (μ). The total cost for the consumer of having a house is therefore given by the financial cost (the payment of interest on the debt) and the depreciation of the property; that is, $(r + \mu)P^V I^V$, also known as the house's usage cost. If the consumer has a nominal income Y^n as a result of her labor, to which the mining income is added, which is a fraction of the mining investment, ϵI^m; does not save; and consumes a

[6] This income is associated with the institutional arrangement in Peru, in which half of the income tax from mining activity is shared out as the *canon minero* among regional governments, municipal governments and public universities.

[7] Strictly speaking, the consumer obtains utility from the housing service, not from the quantity of housing. We are assuming that the housing service is proportional to the quantity of housing.

quantity C of non-durable goods whose unit price is one, then her budget constraint is given by,

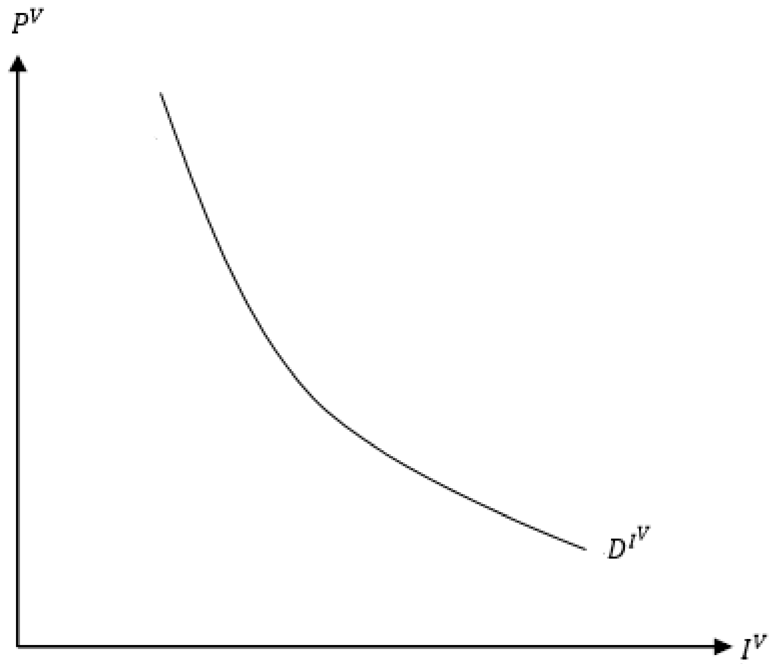
$$Y^n + \epsilon I^m = C + (r + \mu)P^V I^V \qquad (24)$$

The consumer seeks to maximize her utility function (23), subject to her budget constraint, equation (24). From this optimization procedure we obtain the consumer's demand for housing, represented by equation (25) and Figure 4.

$$P^V = \frac{n(Y^n + \epsilon I^m)}{(r+\mu)I^V} \qquad (25)$$

Figure 4

Housing investment demand



According to expression (25), the relationship between the price and the quantity of housing demanded is inverse, while the relationship between family income and mining investment is direct. Moreover, since the family acquires the housing with a mortgage and since the housing is subject to a depreciation rate, the housing price is also inversely related to the interest rate and the depreciation rate.

Determinants of housing investment

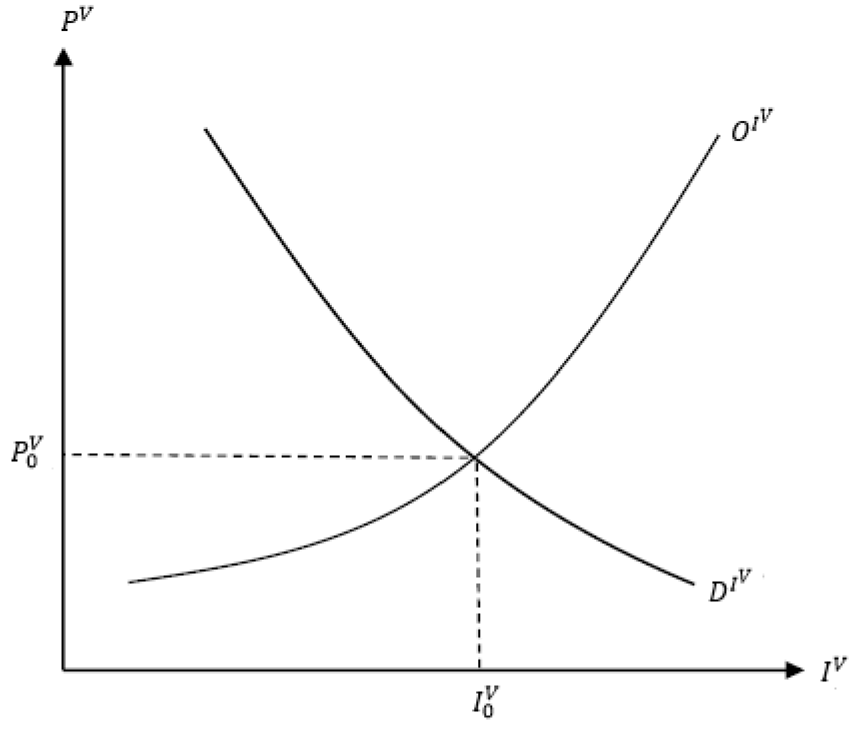
From the housing supply and demand equations —(21) and (25), respectively— we can determine the equilibrium value of the housing volume and price. The equilibrium in the housing market is shown in Figure 5.

$$I^V = A(\beta)^\beta \left[\frac{n(Y^n+\epsilon I^m)}{(r+\mu)C^V}\right]^\beta \tag{26}$$

$$P^V = \frac{(C^V)^\beta}{A(\beta)^\beta}\left[\frac{n(Y^n+\epsilon I^m)}{r+\mu}\right]^{1-\beta} \tag{27}$$

Figure 5

The housing investment market



Consequently, the equation (28) shows that investment in the mining sector of the economy is a direct function of the public infrastructure stock available to the construction industry, consumer income, and mining investment; and an inverse function of the unit cost of housing production, the mortgage interest rate, and the housing depreciation rate.

$$I^V = I^V(A, Y^n, I^m, C^V, r, \mu) \qquad (28)$$

This is the model that we will use to estimate investment in the non-mining sector of this economy.

3.3 Total investment and sector investment

From equations (17) and (28) we can obtain (29) for total investment in this economy (I), mining and non-mining, which depends on a large set of factors linked both to the local and to the national economy.

The reduced form of the complete model is therefore represented by the following system of equations.

$$I = I(A, Y^n, r, u, C^V, \varepsilon, P_x^*, Y_0, r^*, K_{t-1}) \qquad (29)$$

$$I^m = I^m(\varepsilon, P_x^*, Y_0, r^*, K_{t-1}) \qquad (17)$$

$$I^V = I^V(A, Y^n, I^m, C^V, r, \mu) \qquad (28)$$

Where $Y_0 = HK_0^\alpha L_0^\beta [\delta(1-\delta)^t R_0]_0^\gamma$.

This framework of analysis, with the determinants of private investment, gives rise to the central hypothesis or prediction guiding this research: private investment in Peru depends fundamentally on international factors, and the main international factor is the global price of Peru’s exports.

4. FOREIGN AND DOMESTIC DETERMINANTS OF PRIVATE INVESTMENT IN PERU: THE MAIN STYLIZED FACTS

A small open economy such as Peru's is exposed to changes in international conditions. In an earlier study,[8] we found that between 2001 and 2016, 67 percent of the variance in Peru's GDP growth rate was explained by international conditions. Private investment cannot be removed from the enormous influence of international conditions.

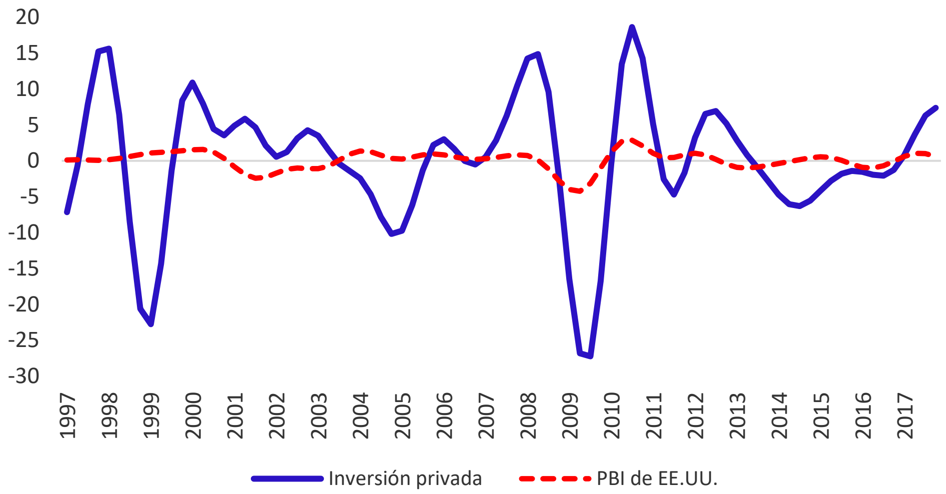
In this section, we present some stylized facts that record the relationship between total private investment, private mining investment, and private non-mining investment, using as references the predictions taken from the theoretical model presented in the previous section. These stylized facts are based on quarterly information for the period 1997:Q1 - 2017:Q4.

All variables, with the exception of the interest rate, are shown in terms of cycles, understood in this case as fluctuations in the growth rate of a variable around its trend growth rate. Following Castillo, Montoro & Tuesta (2006), we employ a frequency filter to obtain the cyclical component. Frequency filters extract the cyclical component from a time series by specifying a range for its duration, and have the advantage of eliminating both the trend and irregular components from the series. However, unlike these authors, who utilize the symmetric frequency filter of Baxter-King (1999), we employ Christiano & Fitzgerald's (2003) asymmetric frequency filter. The difference lies in how the weighted moving average is calculated. In the case of symmetric frequency filters, the weights of the moving averages depend only on the specified frequency band and do not use the data, making them time invariant. Asymmetric frequency filters, on the other hand, allow the weights of the leads and lags to differ, which means that they are dependent on the data and change for each observation. It is worth noting that asymmetric frequency filters, unlike their symmetric counterparts, do not cause the loss of observations either at the start or at the end of the original sample.

[8] Mendoza & Collantes (2017).

Graph 1 shows the behavior of private investment and US GDP. The correlation coefficient between both variables is 0.39, which is relatively high. Private investment is sensitive to external demand, represented by the US GDP growth rate. During this lengthy period, the USA was Peru's main trading partner.[9]

Graph 1
Private investment and US GDP



Source: Compiled by authors.

In Graph 2, we show the connection between private investment and the price of exports. The correlation coefficient is higher, at 0.42. The price of exports will reflect the influence of both the US and the Chinese economies, the latter being Peru's primary trading partner in recent years.

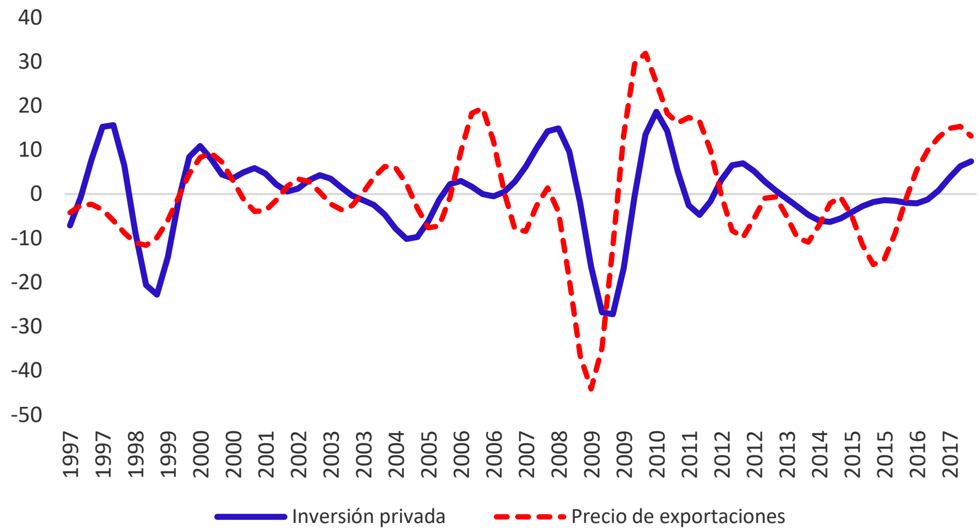
It is worth noting why, unlike numerous authors, here we use the price of exports rather than the terms of trade as the variable that connects us to international trade. First, because our theoretical model contains the price of exports and not the terms of trade. Second, and most importantly, because the terms of trade measure the relationship between export and

9 The correlation coefficient between Chinese real GDP and private investment is 0.21, lower than that recorded for US real GDP. This may be because China's share in Peruvian exports was just seven percent at the end of the 1990s, but currently stands at 26 percent. Moreover, since China is the world's largest commodities importer, its main channel of influence on private investment is through export prices; analysis of the relationship between Chinese GDP and the price of Peruvian exports over the period shows a rather high correlation coefficient of 0.64.

import prices, the use of this indicator assumes there to be symmetry in the effects of export and import prices on the domestic variables.

However, this is questionable. Traditional exports predominate in the export price index, with copper and gold accounting for 42 and 24 percent, respectively, of this category. Meanwhile, the import price index is more "diversified", containing commodities such as petrol and foods, as well as many imported final goods and inputs. Consequently, the effect on the economy of a rise in the price of, say, copper, is known, but it is more difficult to determine the effect of an increase in the price of, for example, wheat, which benefits producers but adversely affects consumers. Hence, in this study we work with the price of exports, the effects of which are clear, and not with the terms of trade.

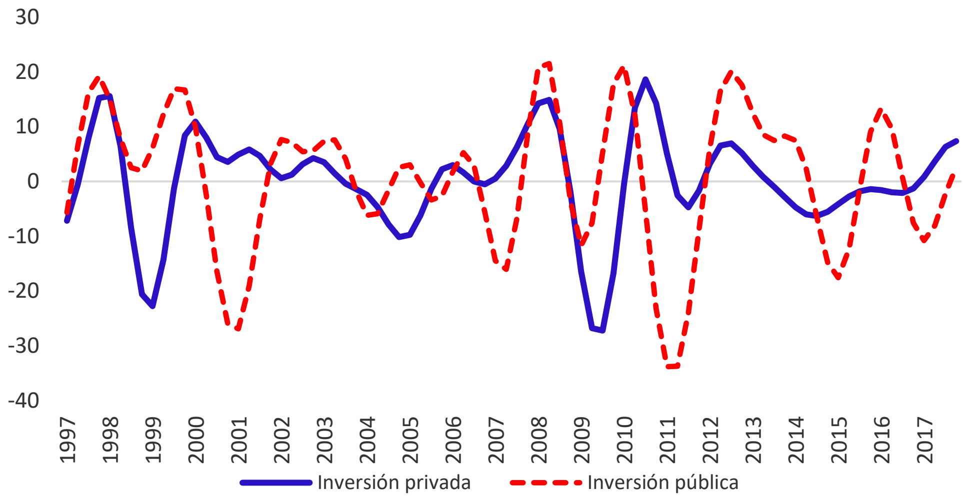
Graph 2
Private investment and the price of exports



Source: Compiled by authors.

Graph 3 shows the connection between private investment and a domestic determinant, public investment. Both can be seen to be positively correlated, as the correlation coefficient is 0.13; this suggests a crowding-in effect, albeit a very weak one.

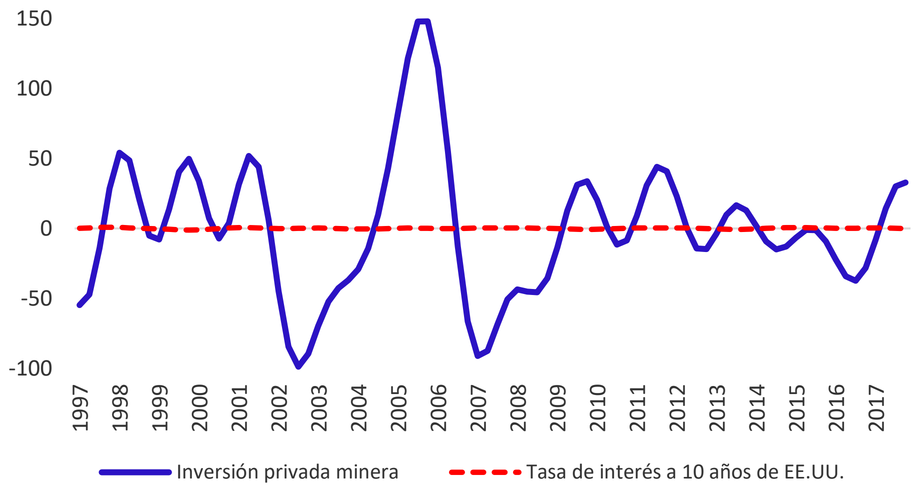
Graph 3
Private and public investment



Source: Compiled by authors.

We will now describe the stylized facts regarding the disaggregated behavior of mining and non-mining investment. Graph 4 shows the relationship between private mining investment and the cost of external financing, represented by the US ten-year international interest rate. The correlation coefficient is -0.15 – negative, as is to be expected, but weak.

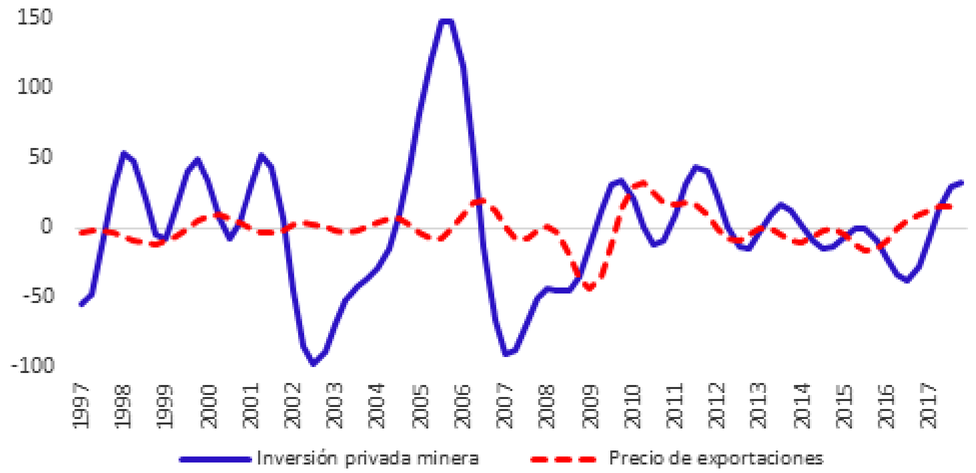
Graph 4
Private mining investment and the US international interest rate



Source: Compiled by authors.

Graph 5 shows a positive, and relatively high, relationship of 0.35 between private mining investment and the price of exports. Private mining investment in Peru appears to be sensitive to the price of exports, which has a large mining component.

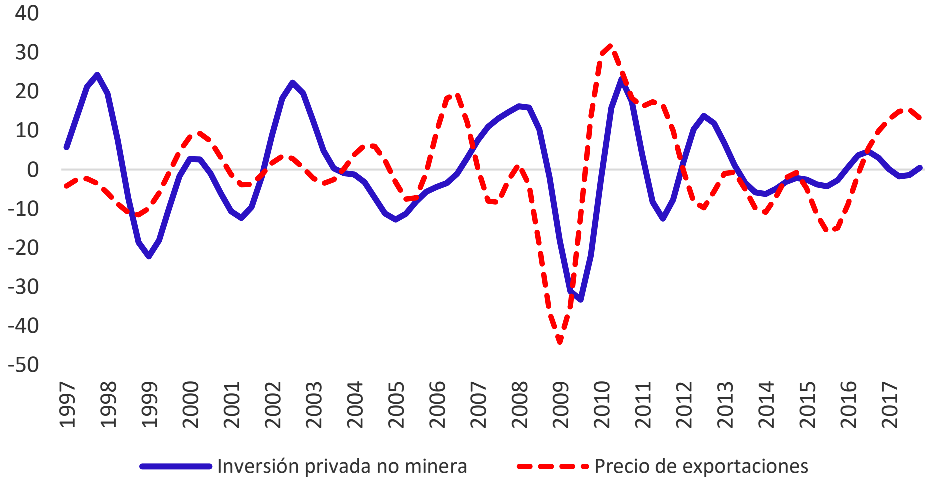
Graph 5
Private mining investment and the price of exports



Source: Compiled by authors.

Graph 6 illustrates the relationship between private non-mining investment and the price of exports. The correlation coefficient is 0.23, which is high. Private non-mining investment in Peru would also appear to be sensitive to the price of exports.

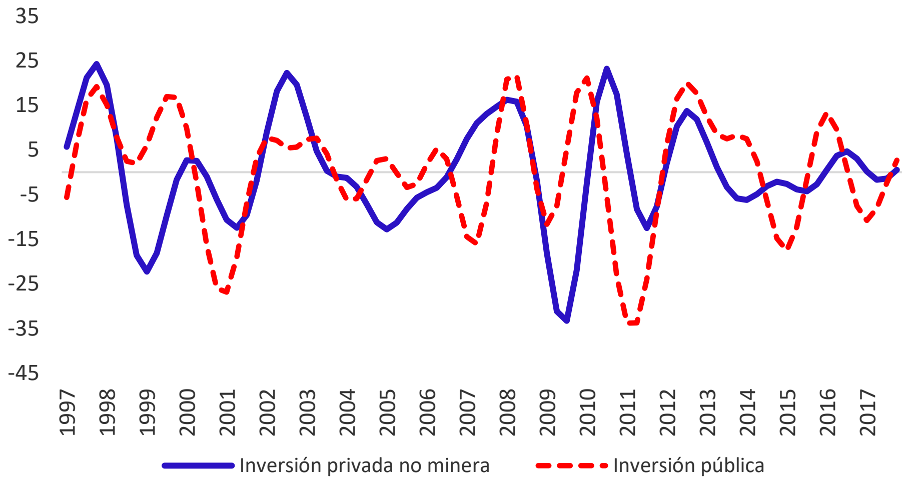
Graph 6
Private non-mining investment and the price of exports



Source: Compiled by authors.

Graph 7 shows the connection between private non-mining investment and public investment. Both can be seen to be positively correlated; the correlation coefficient is 0.26, which suggests a crowding-in effect.

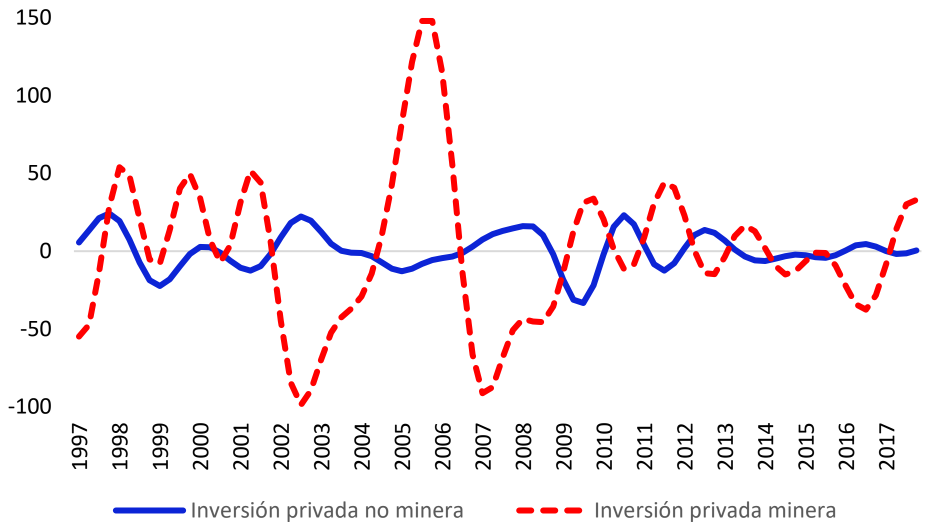
Graph 7
Private non-mining investment and public investment



Source: Compiled by authors.

Finally, Graph 8 presents the connection between private non-mining investment and private mining investment. Both are positively correlated, with a correlation coefficient of 0.28.

Graph 8
Private non-mining investment and private mining investment



Source: Compiled by authors.

In sum, we have found a set of linear relationships between private investment and its possible determinants. There is a high degree of correlation between private investment and the price of exports; this positive and close relationship is sustained when private investment is broken down into mining and non-mining.[10] In the next section, we will explore whether the links between these variables go beyond linear correlations.

[10] In this section, we have not taken into account the connection between private investment and expectations. The reason for this is that we only have access to information on the latter variable —the BCRP's three-month economic expectations index— starting from the second quarter of 2002. Upon analyzing the behavior of these two variables for the period 2002-2017, we find that the correlation coefficient is 0.45. This could lead one to understand that expectations are an important determinant of private investment. However, there could conceivably be a problem of endogeneity, in this case because of the existence of an omitted variable: a determinant of private investment, correlated with expectations. This omitted variable could be the price of exports: an improvement in international prices can have a favorable impact on private —especially mining— investment and, at the same time, on business expectations. Statistically, a correlation coefficient of 0.6 is observed between expectations and the price of exports, which is rather high.

5. EXTERNAL AND DOMESTIC DETERMINANTS OF PRIVATE INVESTMENT IN PERU: IMPULSE-RESPONSE FUNCTIONS, VARIANCE DECOMPOSITION, AND HISTORICAL DECOMPOSITION

In this section, we quantify the importance of foreign and domestic factors on the behavior of overall private investment, private mining investment, and private non-mining investment in Peru for the period 1997-2017, in quarterly frequencies. For this objective, we use the structural vector autoregressions (SVAR) method, using long-term decomposition in order to obtain the impulse-response functions, the decomposition of variance in private investment, and the historical decomposition of annual private investment, discriminating between foreign and domestic determinants.

This method is widely used in empirical analysis. It enables explanation of a variable's behavior, in this case the growth rate of private investment, expressing it as a function of different external and domestic shocks established in the structure of the model. Using an identification process that makes use of long-term restrictions, the private investment growth rate can be expressed in function of shocks with a structural or economic interpretation.

We have closely followed the method of IMF (2015b). In our presentation, as external factors we have considered the US GDP growth rate, the US ten-year treasury interest rate, and the export price growth rate[11]; and the domestic factors are the public investment growth rate, the interbank interest rate, and the private investment growth rate.[12] The difference between this and IMF (2015b) is that the variables we take into account come from the theoretical model; hence, for instance, we have included public investment within the domestic variables. The inclusion of public investment is relevant, as there is evidence of a complementarity effect for the Peruvian economy (Vtyurina & Leal, 2016). Together, the external block variables are an indirect indicator of external economic conditions. US GDP

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11 We have not included Chinese real GDP, since its impact on private investment is already captured through its strong influence on the price of Peruvian exports.

12 The recursive order of the external factors is as follows: the growth rate of US real GDP, the ten-year US treasury rate, and the rise in the price of exports. Meanwhile, the recursive order of the domestic factors is as follows: the public investment growth rate, the domestic interest rate, and the private investment growth rate.

growth and the price increase of Peruvian exports capture the demand shocks. Once the effects of these shocks are discounted, the ten-year US treasury rate expresses the orientation of monetary policy in advanced economies.

Using the same method over the same period as IMF (2015b), we will also explain the behavior of private mining and non-mining investment, considered in our theoretical model, which will allow us to perform our analysis on a more disaggregated basis.[13]

We will begin with a presentation of the impulse-response functions, which show how the variables explained in the system react (respond) to unexpected shocks. A change (shock) in a variable will directly affect the variable itself, and will be transmitted to the remaining variables through the dynamic structure of the model. For example, through this analysis it will be possible to explain the transmission mechanism of an increase in the price of exports in relation to total private investment, private mining investment, and private non-mining investment.[14]

Graphs 9-10 present the responses of the variables from the private investment model to external shock impulses, an increase in the US real GDP growth rate, and an increase in the growth rate of Peruvian export prices.

Graph 9 shows that stronger external demand, represented by the increased growth rate of US real GDP, has a positive effect on private investment. An increase of one percentage point in the US growth rate tends to push up growth in private investment by 0.6 percentage points at the moment of impact; the confidence bands[15] indicate that these effects remain positive over four quarters.

---

13 The recursive order of the external and domestic factors for mining investment is the same as for total private investment. The recursive order of the external factors for non-mining investment is also the same, but in the case of domestic factors, the recursive order is as follows: the growth rate of private mining investment, the growth rate of public investment, the domestic interest rate, and the growth rate of private non-mining investment.

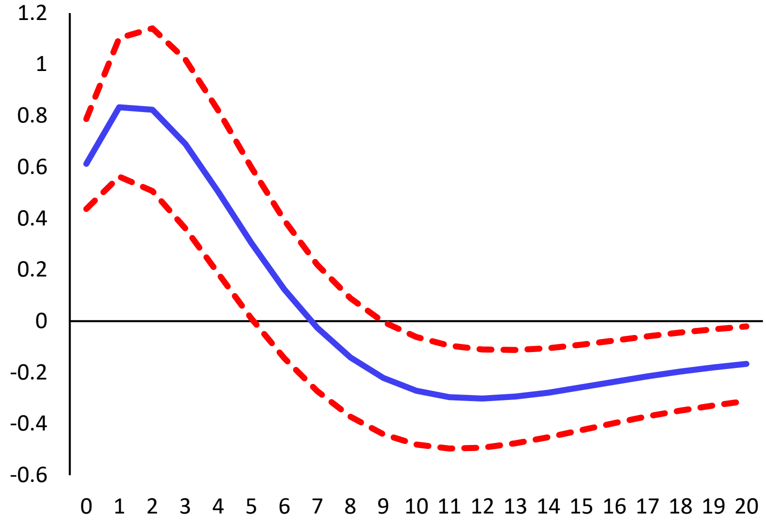
14 For more details, see chapter 11 of Hamilton (1994).

15 We have constructed the confidence bands with a confidence level of 95%.

Graph 9

Response of private investment to an impulse provided by a shock in US real GDP growth

(Percentage points)

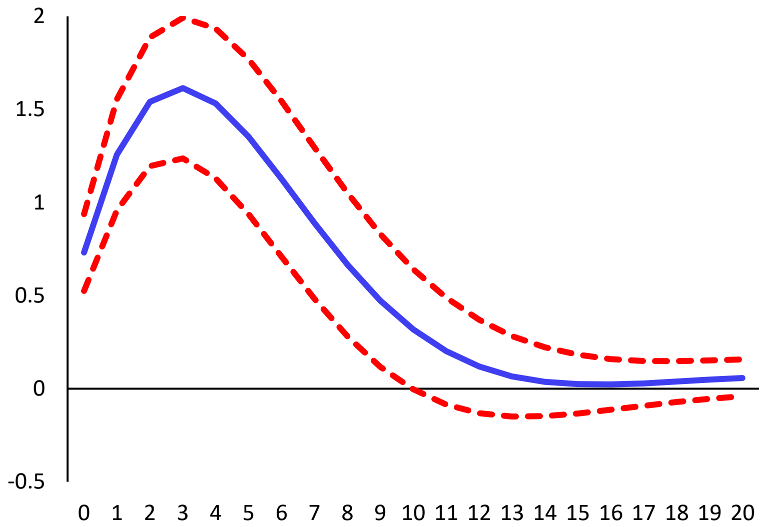


Source: Compiled by authors.

Graph 10 indicates that increased growth in the price of Peruvian exports also has a positive effect on private investment. Moreover, this effect is greater and longer lasting than US real GDP growth. An increase of one percentage point in the growth of the Peruvian export price tends to push up growth in private investment by 0.73 percentage points at the moment of impact, and the effects continue to be positive for more than two years.

Graph 10

Response of private investment to an impulse produced by a shock in the growth of the price of exports
(Percentage points)

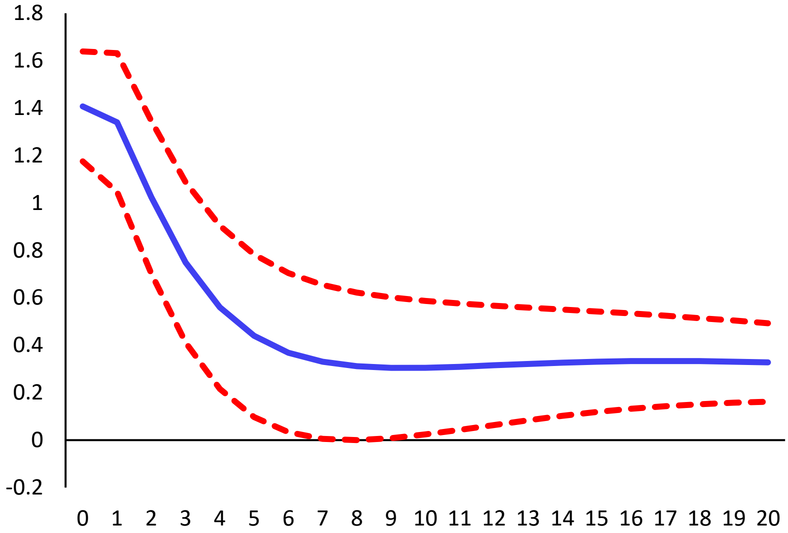


Source: Compiled by authors.

Now we will assess the impulse-response functions of private mining and non-mining investment to an impulse produced by a shock in the growth of the price of exports.

Graph 11 presents the response of private mining investment to an impulse arising from increased growth in the price of Peruvian exports. As shown in Graph 11, increased growth in the price of Peruvian exports has a considerable and positive effect on private mining investment. An increase of one percentage point in the growth in the price of Peruvian exports tends to push up growth in private mining investment by 1.4 percentage points at the moment of impact; the effects remain positive over five quarters.

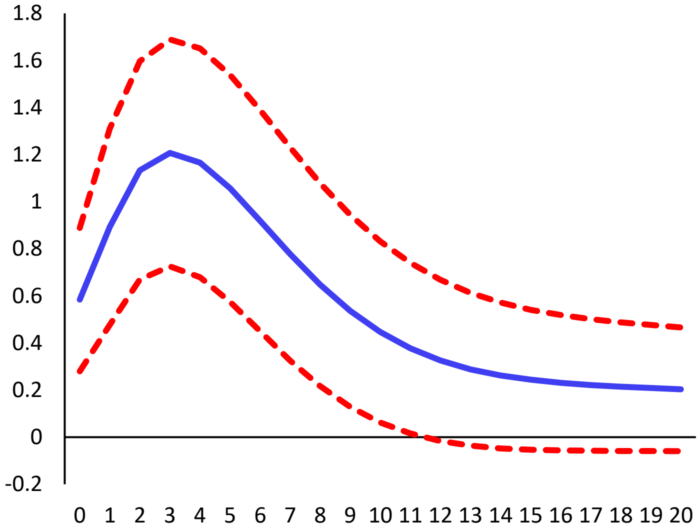
Graph 11
Response of private mining investment to an impulse produced by a shock in the growth of the price of exports
(Percentage points)



Source: Compiled by authors.

Graph 12 presents the response of private non-mining investment to an impulse produced by an increase in the growth of the price of Peruvian exports. It can be seen that increased growth in the price of Peruvian exports has a positive effect on private non-mining investment. However, this effect at the moment of impact is loss pronounced in comparison with the response of private mining investment. An increase by one percentage point in the growth in the price of Peruvian exports tends to push up growth in private non-mining investment by 0.58 percentage points during the moment of impact, and these effects remain positive for two and a half years.

Graph 12
Response of private non-mining investment to an impulse arising from a shock in the grow of the price of exports
(Percentage points)

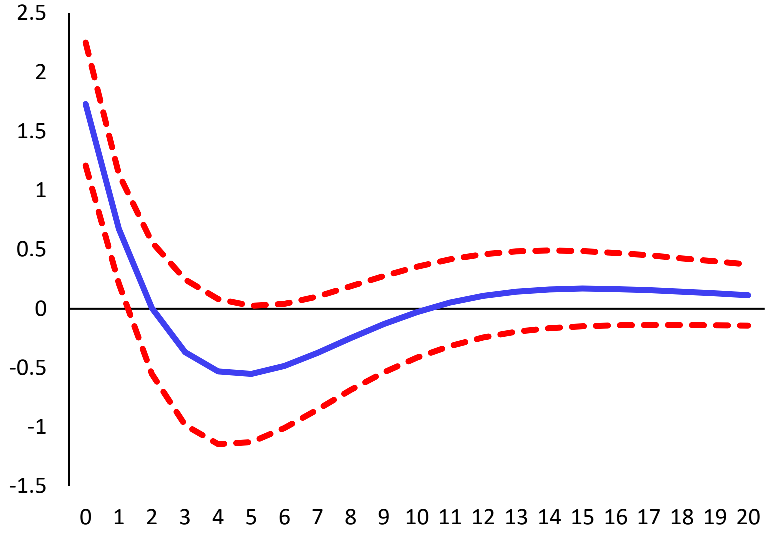


Source: Compiled by authors.

Finally, following the theoretical model, we will now analyze the response of private non-mining investment to an impulse arising from a private non-mining investment growth shock.

Graph 13 presents the response of non-mining private investment to accelerated growth in private mining investment. It can be seen that increased growth in private mining investment has a positive effect on private non-mining investment. An increase by one percentage point in the growth in private mining investment tends to push up growth in private non-mining investment by 1.7 percentage points during the moment of impact, and these effects remain positive for two quarters.

Graph 13
Response of private non-mining investment to an impulse arising from a private mining investment growth shock
(Percentage points)



Source: Compiled by authors.

In sum, we have found that higher growth in US real GDP and in the price of Peruvian exports benefits private investment, whereby the impact of the latter is greater and longer lasting than that of the former. We have also noted that a rise in the price of exports benefits private mining and non-mining exports, and that this effect is greater in the case of private mining investment in comparison with private non-mining investment. Moreover, we have detected that private mining investment has a positive effect on private non-mining investment.

Next, we will seek to quantify the weight of external and domestic factors on the exchange rate variance of total private investment, private mining investment, and private non-mining investment.[16]

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[16] When expectations are included as a domestic variable for the period 2002-2017, the results of the estimations are not altered significantly. The weight of expectations on public investment variance and fluctuations is less than ten percent. When we separate investment into private mining and non-mining, the weight is much lower in the former case.

The variance decomposition lies in obtaining the percentage variability of each variable, as explained by the disturbance in each equation, and can be interpreted as the relative dependence of each variable on the others. While the response function shows the effect that a change (shock) in one of the endogenous variables has on one of the model's other variables, the variance decomposition provides information about the relative importance of each random innovation in the model's variables.[17]

Table 1 shows the variance decomposition of private investment into external and domestic factors. Between the first quarter of 1997 and the fourth quarter of 2017, external determinants explained, on average and in the medium run, 54 percent of the variance in the private investment growth rate in Peru.

The most outstanding finding is that only two variables, the price of commodity exports and US GDP, explain more than half of this variance. The price of exports constitutes the most important individual element within the external determinants.[18] Of the domestic variables, public investment is the dominant individual element.

Table 1
Variance decomposition of the private investment growth rate
1997 Q1–2017 Q4

Factors	Variance in private investment
U.S. GDP	16.02
U.S. ten-year interest rate	13.45
Price of exports	24.76
External factors	**54.23**
Public investment	23.93
Domestic interest rate	1.19
Private investment	20.65
Domestic factors	**45.77**

Source: Compiled by authors.

17 For more details, see chapter 11 of Hamilton (1994).
18 If we include Chinese GDP among the external factors, the weight of the price of exports becomes very limited due to the high correlation between the price of exports and China's GDP.

We have confirmed that shocks derived from the price of Peruvian exports and US GDP have significant repercussions on the growth of private investment in Peru.

Next, based on the historical decomposition, we will estimate the extent to which the growth of private investment, in comparison with its estimated average growth over the sample period, has been determined by external or domestic factors; that is, the extent to which these factors induce, on average, significant fluctuations in the growth of private investment. The historical decomposition involves breaking down the prediction into components associated with the model's structural innovations, which enables estimation of the contribution of different factors to the evolution of the variable of interest.

Table 2 shows the decomposition of fluctuation in the private investment growth rate into external and domestic factors. As can be observed, external factors tended to explain more than half of the deviation in the growth in private investment, in relation to the average estimated for the sample over the last 20 years. Between the first quarter of 1997 and the fourth quarter of 2017, external determinants have explained, on average, 54 percent of private investment fluctuations in Peru in relation to the estimated average, whereby the price of Peruvian exports (26 percent) and US GDP (18 percent) are the most important components in explaining these fluctuations. As to the internal determinants, public investment is the most important individual component, explaining approximately 24 percent of the fluctuations in private investment.

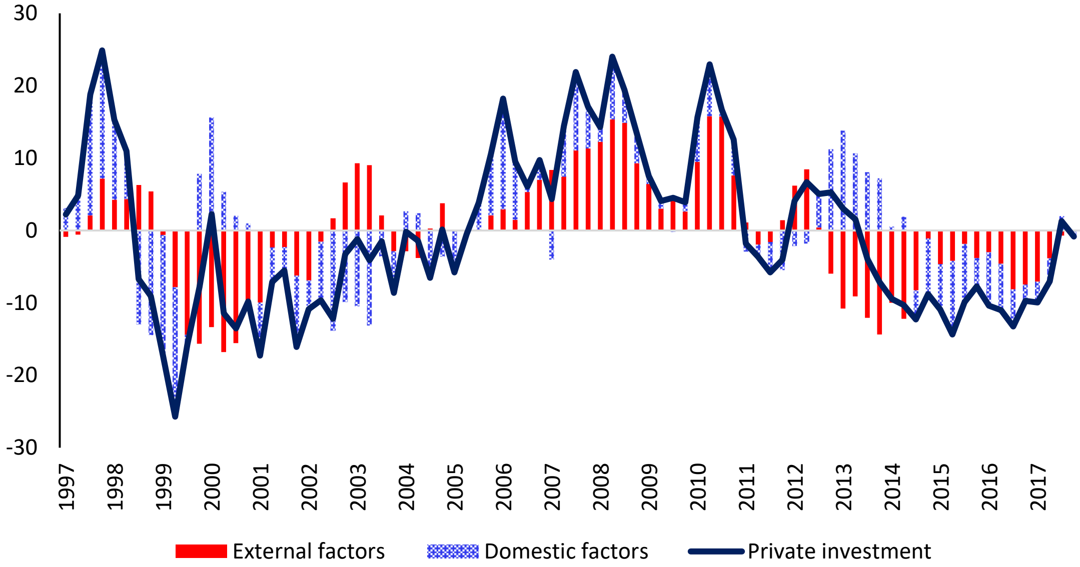
Table 2
Decomposition of fluctuations in the private investment growth rate
1997 Q1–2017 Q4

Factors	Fluctuations in private investment
US GDP	18.00
US. ten-year interest rate	17.77
Price of exports	26.37
External factors	**54.14**
Public investment	23.86
Domestic interest rate	3.63
Private investment	18.37
Domestic factors	**45.86**

Source: Compiled by authors.

Graph 14 presents a historical decomposition of the influence of external and domestic factors on private investment. It is to be expected that the influence of external and domestic factors on fluctuation in the private investment growth rate will have varied over time. It can be seen, for instance, that the weight of external factors on private investment fluctuations in Peru has increased considerably since 2006, in keeping with the rising importance of China as a trading partner and the notable increase in the price of exports.

Graph 14
Historical decomposition of fluctuations in the private investment growth rate
1997 Q1 –2017 Q4



Source: Compiled by authors.

As to the disaggregated investment figures, Table 3 provides a decomposition of the variance in private mining investment into external and domestic factors. Between the first quarter of 1997 and the fourth quarter of 2017, on average and in the medium run, external determinants explained 64 percent of the variance in the private mining investment growth rate in Peru. The most outstanding finding is that just two variables, the price of commodity exports and the long-term international interest rate, account for more than half of this variance. The price of exports constitutes the most important individual element. Of the domestic variables, idiosyncratic shocks constitute the dominant individual element.[19]

19 These idiosyncratic shocks are events or occurrences that have an impact on investment, and are so-called because they are inherent to private mining investment. These events or occurrences might include mining investment legislation, social conflicts, and so on.

Table 3
Variance decomposition of the private mining investment growth rate
1997 Q1–2017 Q4

Factors	**Variance in private mining investment**
U.S. GDP	10.86
US ten-year interest rate	13.35
Price of exports	39.29
External factors	**63.50**
Public investment	6.54
Domestic interest rate	1.32
Private mining investment	28.64
Domestic factors	**36.50**

Source: Compiled by authors.

Table 4 shows the decomposition of fluctuations in the private mining investment growth rate in relation to its estimated average growth rate for the period 1997-2017, into external and domestic factors. Between the first quarter of 1997 and the fourth quarter of 2017, external determinants explained, on average, 62 percent of these fluctuations, whereby the price of Peruvian exports (44 percent) and the long-term international interest rate (15 percent) are the two most important components. Together, they account for more than 50 percent of these fluctuations. As to the internal determinants, idiosyncratic shocks are the most important individual component, representing approximately 22 percent of the fluctuations in private mining investment.

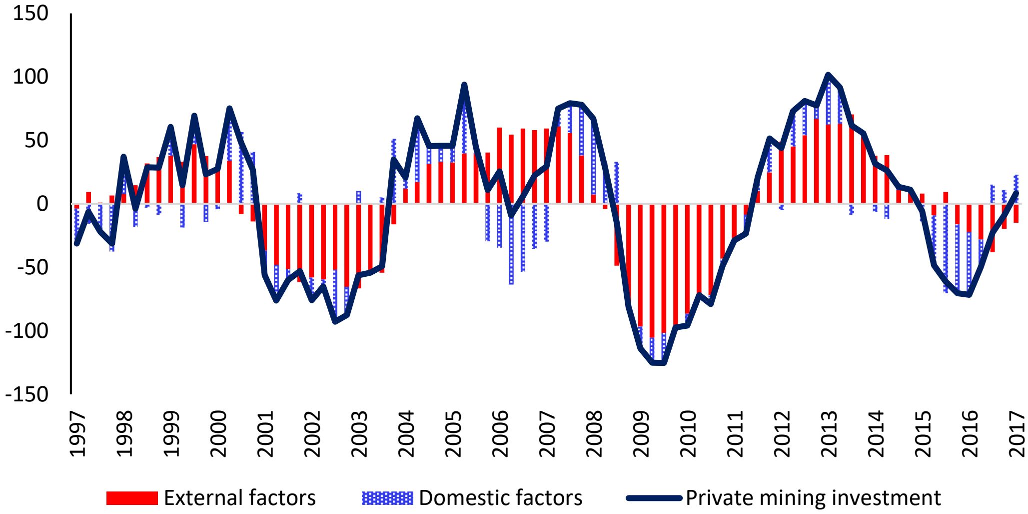
Table 4
Decomposition of fluctuations in the private mining investment growth rate
1997 Q1 –2017 Q4

Factors	**Fluctuations in private investment**
US GDP	3.14
US ten-year interest rate	14.51
Price of exports	44.00
External factors	**61.66**
Public investment	12.13
Domestic interest rate	4.21
Private mining investment	21.99
Domestic factors	**38.34**

Source: Compiled by authors.

Graph 15 shows the historical decomposition of the private mining investment growth rate in relation to its estimated average. The greater contribution of external factors is particularly evident with respect to the last two recessions that originated in the advanced economies: at the start of the 2000s, and the global financial crisis of 2008-2009. Moreover, external factors contributed more at the start of the rapid expansion in private mining investment during the period that followed the global financial crisis. Finally, internal factors appear to have been curbing growth in private investment in recent years, starting from the final quarter of 2014.

Graph 15
Historical decomposition of fluctuations in the private mining investment growth rate
1997 Q1–2017 Q4



Source: Compiled by authors.

Table 5 shows the variance decomposition of the private non-mining investment growth rate into external and domestic factors. Between the first quarter of 1997 and the final quarter of 2017, on average and in the medium run, external determinants explained 38 percent of the variance in the private non-mining investment growth rate in Peru, whereby the price of Peruvian exports (23 percent) was the single most important factor. As is to be expected, domestic factors have a greater bearing on non-mining investment, accounting for 62 percent of the variance, with public investment the most important individual component (35 percent).

Table 5
Variance decomposition of the private non-mining investment growth rate
1997 Q1–2017 Q4

Factors	Variance in private non-mining investment
US GDP	3.72
US ten-year interest rate	11.38
Price of exports	23.30
External factors	**38.40**
Mining investment	10.52
Public investment	34.72
Domestic interest rate	3.70
Private non-mining investment	12.66
Domestic factors	**61.60**

Source: Compiled by authors.

Table 6 shows the decomposition of fluctuations or cycles of the private non-mining investment growth rate in relation to its estimated average growth, into external and domestic factors. Between the first quarter of 1997 and the fourth quarter of 2017, external determinants explained, on average, 39 percent of these fluctuations, whereby the price of Peruvian exports was the single most important component. As to the domestic determinants, public investment remains the most important individual component, representing 25 percent of the fluctuations in private mining investment.

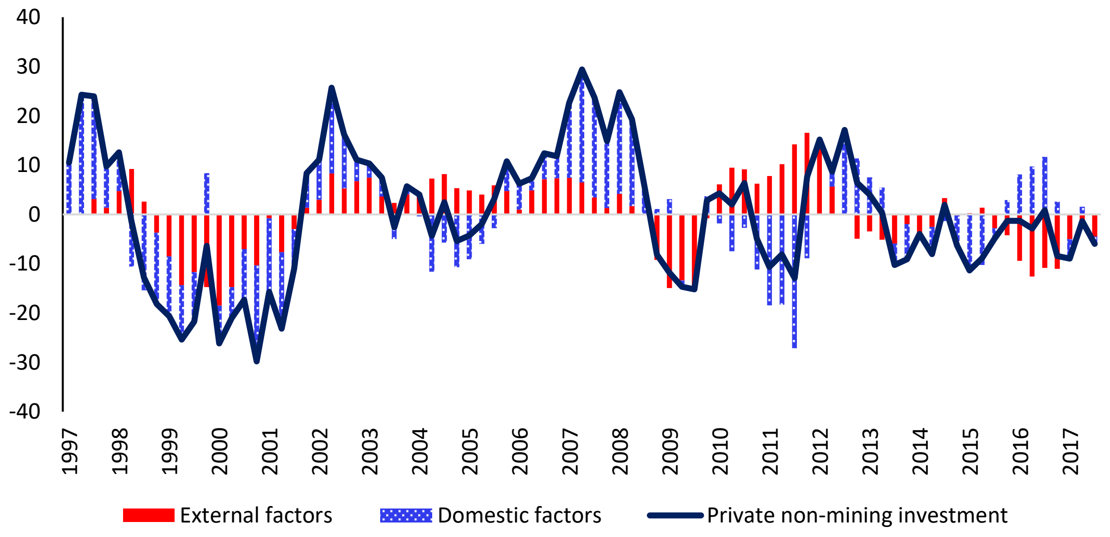
Table 6
Decomposition of fluctuations in the private non-mining investment growth rate
1997 Q1 –2017 Q4

Factors	Fluctuations in private non-mining investment
US GDP	7.76
US ten-year interest rate	12.45
Price of exports	18.67
External factors	**38.89**
Mining investment	12.63
Public investment	25.11
Domestic interest rate	5.45
Private non-mining investment	17.93
Domestic factors	**61.11**

Source: Compiled by authors.

Graph 16 presents the historical decomposition of private non-mining investment, into domestic and external factors. As can be seen, the influence of domestic factors on fluctuations in private non-mining investment is much greater in comparison with private mining investment.

Graph 16
Historical decomposition of fluctuations in the private non-mining investment growth rate
1997 Q1–2017 Q4



Source: Compiled by authors.

6. CONCLUSIONS AND ECONOMIC POLICY IMPLICATIONS

In this study, we have identified the enormous influence of international conditions on the evolution in the growth rate of total private investment, mining investment, and non-mining investment in Peru over the period 1997-2017, and the extraordinary individual influence of the price of exports in this evolution. Thus, our central hypothesis has been corroborated.

An unforeseen increase of one percentage point in the growth in the price of exports pushes up growth in private non-mining investment by 0.7 percentage points at the moment of impact, and the effects remain positive over nine quarters. This increase in the growth rate of the Peruvian export price benefits private mining investment more than it does private non-mining investment. In the former case, the increase at the moment of impact is 1.4 percentage points, while in the latter it is 0.58 percentage points. Moreover, private mining investment has a positive effect on private non-mining investment. An increase of one percentage point in the growth rate of private mining investment pushes up growth in private non-mining investment by 1.7 percentage points.

On average, in the period of study, external factors account for 54, 64, and 38 percent of the variance in the growth rates for total private investment, mining investment, and non-mining investment, respectively. One component of the external factors, the price of exports, represents 25, 39, and 23 percent of the variance in the growth rates for total private investment, mining investment, and non-mining investment, respectively. If in each of the calculations we replace the price of exports with the price of copper, the results remain largely unaltered. It is possible to affirm, then, that the price of copper has an enormous influence on the behavior of private investment in Peru.

On the other hand, in the period of study, internal factors explained 46, 36, and 62 percent of the variance in the growth rates for total private investment, mining investment, and non-mining investment, respectively. One component of the internal factors, public investment, accounted for 24, six, and 35 percent of the variance in the growth rates for total private investment, mining investment, and non-mining investment, respectively.

These findings are important because they have helped us to identify both the most important channel connecting private investment in Peru with the world economy the price of exports, or the price of copper; and the macroeconomic policy variable that could prove most effective in reducing the extent of fluctuations in private investment: public investment.

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Databases

Each of the series are presented in quarterly frequencies. Peru's average interbank interest rate in national currency, export price index (2007=100), three-month economic expectations index, real public investment in million soles of 2007, and real private investment in million soles of 2007 were obtained from the website of the Central Reserve Bank of Peru. US real GDP in billion dollars of 2009 and the US ten-year interest rate were obtained from the website of the Federal Reserve Bank of St. Louis. Private mining investment in dollars were obtained from the website of Peru's Ministry of Energy and Mines. Real private mining investment has been built using the nominal average exchange rate and the total private investment deflator. Real private non-mining investment is the residual between the total private investment minus the private mining investment.

	US real GDP	US interest rate	Price of exports	Real public investment
1996Q1	10348.69	5.91	44.75	2037.00
1996Q2	10529.38	6.71	45.29	1951.49
1996Q3	10626.78	6.78	42.46	2090.48
1996Q4	10739.06	6.35	44.13	2793.10
1997Q1	10820.91	6.57	44.68	1848.04
1997Q2	10984.15	6.70	45.07	2169.78
1997Q3	11124.01	6.24	45.32	2574.86
1997Q4	11210.33	5.91	43.17	3554.93
1998Q1	11321.25	5.59	42.03	2207.14
1998Q2	11431.05	5.59	42.06	2529.71
1998Q3	11580.59	5.21	40.88	2805.36
1998Q4	11770.69	4.66	38.23	3319.22
1999Q1	11864.68	5.00	37.35	2271.04
1999Q2	11962.52	5.54	36.83	2955.33
1999Q3	12113.08	5.88	37.70	3401.78
1999Q4	12323.34	6.14	39.92	3378.27
2000Q1	12359.10	6.47	39.59	2498.27
2000Q2	12592.53	6.18	38.40	2664.41
2000Q3	12607.68	5.89	39.48	2299.12
2000Q4	12679.34	5.57	38.71	2740.68
2001Q1	12643.28	5.04	38.41	1377.20
2001Q2	12710.30	5.28	37.46	2042.45
2001Q3	12670.11	5.00	37.61	1688.97
2001Q4	12705.27	4.76	36.87	2685.45
2002Q1	12822.26	5.08	37.68	1428.70

2002Q2	12893.00	5.11	39.35	1833.54
2002Q3	12955.77	4.27	39.81	1751.19
2002Q4	12964.02	4.00	40.87	2299.42
2003Q1	13031.17	3.92	41.70	1540.91
2003Q2	13152.09	3.62	40.80	1808.67
2003Q3	13372.36	4.23	42.97	1668.35
2003Q4	13528.71	4.29	46.35	2460.79
2004Q1	13606.51	4.01	52.69	1283.37
2004Q2	13706.25	4.60	53.57	1505.88
2004Q3	13830.83	4.30	53.58	1808.72
2004Q4	13950.38	4.18	57.39	2868.55
2005Q1	14099.08	4.30	59.93	1265.64
2005Q2	14172.70	4.16	62.50	1601.49
2005Q3	14291.76	4.22	65.29	1851.11
2005Q4	14373.44	4.49	69.63	3506.21
2006Q1	14546.12	4.58	75.59	1350.03
2006Q2	14589.59	5.07	89.89	1913.69
2006Q3	14602.63	4.89	92.83	2312.30
2006Q4	14716.93	4.63	92.42	4088.75
2007Q1	14726.02	4.68	91.36	1337.73
2007Q2	14838.66	4.85	101.45	2083.98
2007Q3	14938.47	4.74	102.55	2679.74
2007Q4	14991.78	4.27	104.64	5220.27
2008Q1	14889.45	3.67	109.62	2078.03
2008Q2	14963.36	3.88	115.67	3017.60
2008Q3	14891.64	3.86	108.92	3610.15
2008Q4	14576.99	3.23	80.92	5650.35
2009Q1	14375.02	2.74	77.30	2570.89
2009Q2	14355.56	3.32	85.28	3508.55
2009Q3	14402.48	3.52	94.24	4822.46
2009Q4	14541.90	3.46	105.64	8191.43
2010Q1	14604.85	3.72	111.63	3036.67
2010Q2	14745.93	3.49	115.76	5012.07
2010Q3	14845.46	2.78	116.19	5627.97
2010Q4	14939.00	2.88	129.16	8288.71
2011Q1	14881.30	3.46	140.12	2497.74
2011Q2	14989.56	3.20	146.24	3618.50
2011Q3	15021.15	2.41	148.31	4461.79
2011Q4	15190.26	2.05	139.93	8931.12
2012Q1	15291.04	2.04	143.11	3275.42
2012Q2	15362.42	1.83	139.11	4426.76
2012Q3	15380.80	1.64	137.42	5522.36
2012Q4	15384.25	1.71	142.23	10082.07
2013Q1	15491.88	1.95	143.52	3737.21
2013Q2	15521.56	1.99	131.46	5639.08

2013Q3	15641.34	2.71	127.95	6442.93
2013Q4	15793.93	2.74	126.97	10068.27
2014Q1	15757.57	2.77	126.55	4051.32
2014Q2	15935.83	2.62	123.98	5367.14
2014Q3	16139.51	2.50	125.29	6265.87
2014Q4	16220.22	2.28	117.75	9915.37
2015Q1	16349.97	1.97	109.61	3031.14
2015Q2	16460.89	2.16	108.55	4765.29
2015Q3	16527.59	2.22	102.19	5855.69
2015Q4	16547.62	2.19	99.54	9525.82
2016Q1	16571.57	1.91	95.83	3984.59
2016Q2	16663.52	1.75	98.71	5057.66
2016Q3	16778.15	1.56	102.89	5876.59
2016Q4	16851.42	2.14	106.59	8300.03
2017Q1	16903.24	2.45	111.22	3290.86
2017Q2	17031.09	2.26	108.15	4765.69
2017Q3	17163.89	2.24	114.38	6196.06
2017Q4	17286.50	2.37	123.22	8313.97

	Interbank interest rate	Real private investment	Private mining investment	Expectations index
1996Q1	11.24	7291.92	101561248.05	
1996Q2	12.74	7817.34	125608142.70	
1996Q3	12.42	7937.30	84950424.15	
1996Q4	16.81	8200.44	143217083.46	
1997Q1	15.17	7963.67	83092813.80	
1997Q2	12.80	8469.34	91518366.45	
1997Q3	10.49	9557.20	105482698.62	
1997Q4	13.78	10250.79	99757106.79	
1998Q1	14.52	9139.31	230792320.59	
1998Q2	16.35	9335.39	153992027.40	
1998Q3	28.56	8873.35	112062174.90	
1998Q4	13.82	8024.95	164138991.21	
1999Q1	19.67	7032.18	191048780.37	
1999Q2	13.51	7133.98	172018469.40	
1999Q3	9.41	7905.65	232370389.02	
1999Q4	17.15	7909.19	288929370.51	
2000Q1	13.48	7666.97	223766511.03	
2000Q2	14.38	6800.72	284648571.57	
2000Q3	11.01	7354.57	242244979.08	
2000Q4	12.72	7638.74	335959492.44	
2001Q1	10.69	6835.21	372388222.17	
2001Q2	13.73	6771.88	392684102.10	
2001Q3	6.64	7476.44	556099625.58	
2001Q4	3.33	7005.47	273899803.59	
2002Q1	2.60	6669.33	151811387.16	
2002Q2	2.53	6729.81	191501236.89	56.67
2002Q3	3.75	7277.02	103237365.57	57.00
2002Q4	3.87	7468.85	82483493.40	65.67
2003Q1	3.79	7263.93	77686151.13	66.00
2003Q2	3.79	7141.40	80923091.73	58.00
2003Q3	3.08	7917.07	65092080.75	57.00
2003Q4	2.56	7592.61	81178480.56	59.33
2004Q1	2.47	7995.79	76595178.06	56.33
2004Q2	2.48	7768.45	77415232.95	56.67
2004Q3	2.61	8202.15	115674860.34	60.33
2004Q4	3.01	8368.61	126610713.39	63.00
2005Q1	2.94	8332.65	148852096.92	63.00
2005Q2	3.01	8496.81	234422147.10	64.00
2005Q3	2.99	9321.57	327336453.75	65.33
2005Q4	3.18	10065.97	375122460.39	61.00
2006Q1	3.84	10649.13	404010366.24	54.00
2006Q2	4.48	10108.32	396351938.22	60.00
2006Q3	4.48	10754.41	389522640.72	68.67

2006Q4	4.50	11970.13	420029775.51	71.67
2007Q1	4.49	12071.91	289989401.85	72.67
2007Q2	4.51	12465.38	300834938.16	72.67
2007Q3	4.81	14045.49	312497333.53	69.67
2007Q4	4.99	15043.23	345494048.67	72.67
2008Q1	4.89	14806.42	375030630.32	69.33
2008Q2	5.53	16481.29	423987989.74	71.33
2008Q3	6.18	17907.55	459018454.29	61.33
2008Q4	6.54	17244.95	450022231.94	41.00
2009Q1	6.36	14748.12	351539579.47	35.33
2009Q2	4.24	13848.45	814342705.57	47.67
2009Q3	1.59	15611.24	737452065.22	59.00
2009Q4	1.23	16358.01	918327438.55	67.33
2010Q1	1.15	17021.99	764540318.58	71.67
2010Q2	1.43	18039.03	969806506.05	73.33
2010Q3	2.34	20170.92	1058984891.57	70.67
2010Q4	2.97	20934.78	1276112947.79	69.67
2011Q1	3.43	19496.11	1142800112.74	65.33
2011Q2	4.16	20241.27	1799453671.29	47.33
2011Q3	4.25	21950.34	1775033370.15	51.67
2011Q4	4.26	22830.23	2529835425.63	57.33
2012Q1	4.24	22569.87	1571679938.87	60.33
2012Q2	4.24	23740.01	2058706175.39	60.67
2012Q3	4.23	25223.84	2279222963.15	58.67
2012Q4	4.24	26187.80	2593970876.42	64.00
2013Q1	4.20	25327.34	1971141335.39	66.00
2013Q2	4.24	26260.84	2492716036.77	55.00
2013Q3	4.37	26471.70	2372010742.14	50.33
2013Q4	4.17	26600.46	3159566225.59	56.00
2014Q1	4.10	25082.54	2169751738.47	57.67
2014Q2	4.00	25707.23	2181906345.55	52.33
2014Q3	3.77	25301.00	2189494151.56	51.00
2014Q4	3.66	26246.54	2453049911.94	53.67
2015Q1	3.38	24123.63	1814515850.96	51.00
2015Q2	3.47	23738.57	1784549517.54	47.67
2015Q3	3.58	24401.60	1979726413.39	44.00
2015Q4	3.60	25798.64	2116189783.95	45.00
2016Q1	4.46	23003.23	1020902440.95	45.33
2016Q2	4.42	22429.05	992609944.07	53.67
2016Q3	4.24	22433.78	1054312166.25	61.67
2016Q4	4.30	24570.10	1199995863.58	58.67
2017Q1	4.25	21795.49	868958173.00	52.00
2017Q2	4.12	21853.71	1091701853.00	53.67
2017Q3	3.73	23674.94	1296572461.00	57.00
2017Q4	3.37	25347.84	1664129136.00	60.33

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