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ARTICLE



The effect of output growth volatility on output growth: empirical evidence from Turkey

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ABSTRACT

This article assesses the effect of output growth volatility on output growth within a stochastic-volatility-in-mean model with a time-varying framework for an open small economy: Turkey. Until now, the empirical evidence on industrial production mainly reveals that this relationship is negative. However, in further examining different sectors and sub-sectors of industrial production, we find the sign of the relationship changes depending on the sector. Moreover, there is limited evidence that the sign of the relationship changes over time. Thus, the evidence reveals that the nature of the output growth volatility–output growth relationship is not uniform across sectors.

KEYWORDS

Output growth volatility; output growth; TVP-SVM

JEL CLASSIFICATION

E23; E10; O40; C52

1. Introduction

The link between output and its volatility is one of the most examined issues in macroeconomics, and there are various arguments on the nature of this relationship.¹ Friedman (1968) argues that output and volatility are independent from each other. Sandmo (1970) and Black (1987) argue that output volatility has a positive effect on output. Keynes (1936), Pindyck (1991), and Ramey and Ramey (1995), the last of which is considered a benchmark empirical study of the relationship between aggregate output and its volatility, argue that the effect of output volatility on output is negative. Hakura (2007) supports the negative effect and reports that emerging economies are more sensitive to aggregate output volatility than developed economies. Imbs (2007) investigates this relationship across countries as well as across sectors. He reports that even if the relationship is negative across countries, it is positive across sectors. The present study is an attempt to understand the relationship between output volatility and output by considering its sub-components on different sectors individually across time. To be specific, we investigate the relationship between industrial production and its volatility on the

aggregate industrial production (IP) level and its sub-sectors for an important emerging economy – Turkey – by using Chan's (2017) novel stochastic-volatility-in-mean model with time-varying parameters (TVP-SVM).

Friedman (1968), Phelps (1968), and Lucas (1972) use misperception theory, which suggests no relationship between output and its volatility. They argue that the main factors of output growth are real factors such as labour and technology, and that price misperceptions, which are the result of monetary shocks, cause fluctuations in output. Thus, there should be no relationship between output and its volatility. This argument is a reflection of the standard classic dichotomy in macroeconomics, which suggests that there is no relationship between output and its volatility. There are also empirical studies that support the above authors' proposition. For example, Speight (1999) finds no significant relationship between output variability and growth using models of generalized autoregressive conditional heteroscedasticity (GARCH) in the mean for the UK, which were applied to post-war monthly industrial production data. Fang and Miller (2008) report no statistically significant relationship between output

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¹See Tsouma (2014) for a theoretical and empirical literature review.

growth rate and its volatility for the US between 1947 and 2006.

The positive effect of output volatility on output can be observed under the condition of precautionary saving or investment on high-return technologies. Sandmo (1970) argues that higher income volatility causes a higher saving rate for precautionary reasons, which results in a higher growth rate. Black (1987) claims that investment in riskier technologies is realized when there is a high return expectation, therefore leading to a higher growth rate. More recent empirical studies that present the positive impact of output volatility on output include Lee (2010) and Zagler (2016). Lee (2010) reports a positive effect of volatility on output growth for G7 countries between 1965 and 2007 using a dynamic panel GARCH specification. Zagler (2016) shows a positive relation between long-run output volatility and economic growth for 25 OECD countries using data between 1960 and 2013. Economic structure and other externalities may also affect the relationship between output volatility and output. For example, Dawson (2015) considers the role of economic freedom in the output and output volatility nexus for a diverse sample of 99 countries. He shows that output volatility more likely has a negative effect in low-freedom countries. Indeed, empirical studies report a positive effect of output volatility on output, especially for developed countries. Thus, this finding may suggest that the nature of volatility impact on output can be negative for emerging economies.

The adverse effect of output volatility on output is based on the proposition of Keynes (1936), who claims that when making a decision about investment, investors consider economic conditions. High output volatility is considered a risk for investment, which reduces the demand for it. Therefore, output growth should be lower. Pindyck (1991) elaborates on irreversible investment expenditures and political and economic instability, which negatively affect the decision to invest. Moreover, uncertainty has a negative effect on investment, and hence an adverse effect on growth rate. Ramey and Ramey (1995), in their pioneering empirical study, show that higher output volatility results in lower growth rates for 92 countries. Dabušinskas, Kulikov, and Randveer

(2013) reinforce Ramey and Ramey's (1995) result, showing a negative impact of output volatility in a panel of 121 countries between 1980 and 2010. Hakura (2007) finds that in addition to its negative effect, the effect of output volatility is bigger in developing countries than in developed countries. Furthermore, Kose, Prasad, and Terrones (2006) show a basic negative association between output volatility and growth during the 1990s, and emphasize that both trade and financial integration significantly weaken this negative relationship.

In addition to these panel studies, the output volatility–growth relationship has been examined for single-country cases. For example, Berument, Dincer, and Mustafaoglu (2012) present the negative impact of growth volatility on growth for Turkey between 1987 and 2007. Tsouma (2014) investigates the negative impact for Greece from 1975 to mid-2013. Therefore, the negative impact of aggregate output volatility on aggregate output is an accepted suggestion, especially for emerging economies.

Overall, one may expect a negative effect of output volatility on output for developing or emerging economies, as well as low economic freedom. However, individual sectoral growth and its volatility association is a hitherto neglected topic. To the best of our knowledge, there has been no study exploring this relationship for different sectors. The only study that considers sectoral data is Imbs' (2007) work, and he considers the relationship *across* sectors rather than on individual sectors at a certain time. He reports a negative relationship across countries but a positive relationship across sectors. In an earlier version of the article (Imbs 2002, 16), he calls this phenomenon an example of 'Simpson's fallacy.' The current article, to the best of our knowledge, is the first that considers this relationship for a set of sectors.

On the econometric methodology for the effects of output volatility on output, the main methodology to assess this relationship is an ARCH-type model that provides the direct effect of a variable's conditional variance on its level (Evans 1991). Koopman and Uspensky (2002) propose the SVM model, which enables observing variability as a stochastic variable rather than as a

deterministic variable, as occurs in ARCH-type models. Chan (2017) extends the SVM model with TVPs to explore the effect of volatility on output growth (the TVP-SVM model).

Our methodology incorporates possible structural breaks between output growth volatility and the output growth relationship that previous methodologies seem to have overlooked. This article examines the impact of output growth volatility on output growth for different aggregation levels in Turkey, an important emerging economy and the seventeenth largest in the world in 2015 (according to the World Bank's PPP-based² GDP ranking). As Turkey also has a large variability in output (see Figure 1(b)), there is a low change in

type-II error (failing to reject the null when it is false) for the data.

The contributions of the article are as follows: First, this is the premier article to consider growth and its volatility association using a TVP model, which allows us to compare the effect of output growth volatility across time. Second, this article assesses growth and its volatility at different aggregation levels as well as for different sub-sectors for a single country.

The empirical evidence gathered from the NACE Rev.2 classification industrial production (IP) series suggests that the effect of output growth volatility on output growth is negative. When this parameter is estimated for the three

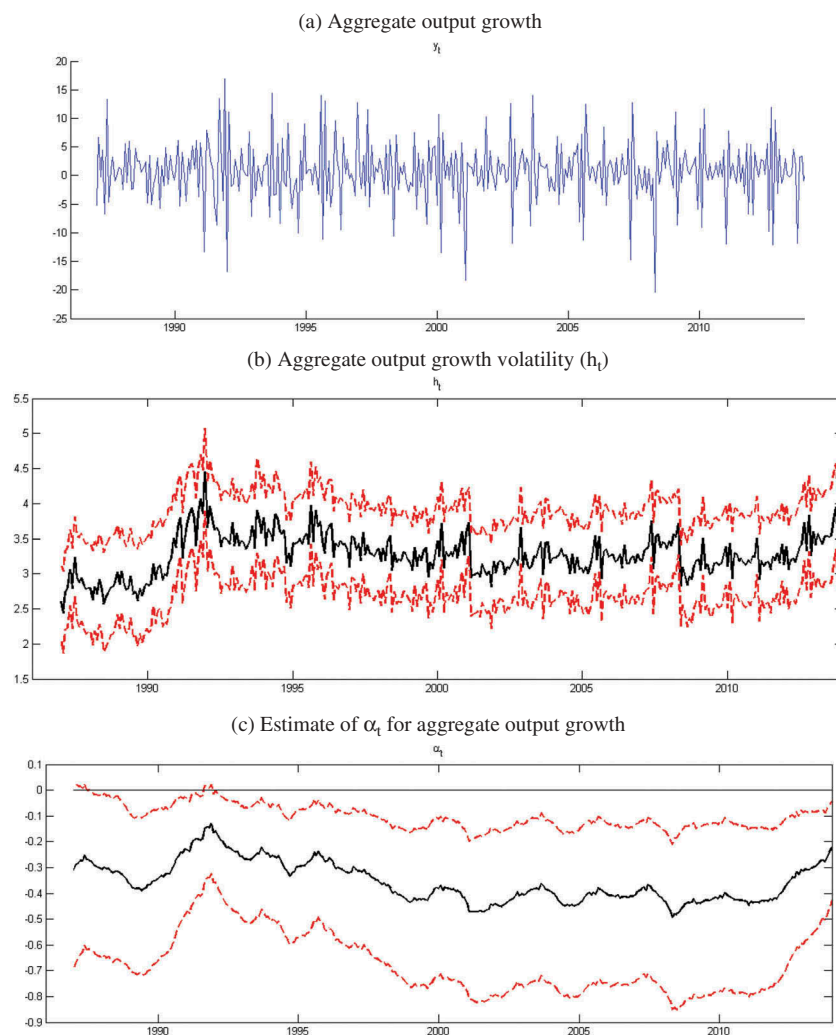


Figure 1. Aggregate level for the period 1986:01 to 2016:01.

Note: The solid line is the estimation and the dashed lines are the 10% confidence band.

²See <http://data.worldbank.org/data-catalog/GDP-PPP-based-table>.

main sectors of IP, the effect is positive for Mining & Quarrying, negative for Manufacturing, and positive but not statistically significant for Electricity & Gas. When we look at the four sub-sectors of Mining & Quarrying, the effects are negative for Mining of Coal & Lignite, and positive for Extraction of Crude Petroleum & Natural Gas, Mining of Metal Ores, and Other Mining & Quarrying. When we look at the sub-sectors of Manufacturing, this effect is positive for six of the nine that we consider and negative for three of them. For the sub-sectors with a negative relationship, only one of these is statistically significant. Last, the relationship between output growth and its volatility decreases just after the 2008 financial crises for the sub-sectors of Manufacturing as well as for Mining & Quarrying, but the sign of the relationship is unaltered across time. Thus, we see that the nature of the relationship changes across sectors.

The article is set out as follows: Section 2 describes the data and Section 3 presents the methodology. Section 4 discusses the empirical results and Section 5 concludes.

II. Data

We gathered all data from the Electronic Data Delivery System of the Central Bank of the Republic of Turkey. The time span that we employ is from January 1986 to January 2016. As noted above, the monthly IP series for aggregate output and its three main sectors (Mining & Quarrying, Manufacturing, and Electricity & Gas) were selected according to the NACE Rev.2 classification. Manufacturing covers 30 sub-sectors. We selected nine of these sub-sectors (see Figure 2) to demonstrate the different natures of the relationship between output growth volatility and output growth. To the best of our knowledge, no sub-sector data are available for Electricity & Gas. For Mining & Quarrying, the data set consists of all four sub-sectors (see Table A1). Data with NACE Rev.2 classification is only available after January 2005; therefore, the data for the Manufacturing and Mining & Quarrying sub-sectors are from January 2005 to January 2016. To account for seasonality, we use the X12 procedure. We calculate the growth rate for each series by $y_t = 100 \times$

$(Z_t - Z_{t-1})/Z_{t-1}$, where Z_t is the series of interest at time t . A description of each series is given in Table A.1 of the Appendix.

III. Methodology

To investigate the impact of output volatility on output, we employ the TVP-SVM model introduced by Chan (2017), which can be given as follows:

$$y_t = \beta_t + \alpha_t e^{h_t} + \varepsilon_t^y, \text{ where } \varepsilon_t^y \sim N(0, e^{h_t}) \quad (1)$$

$$h_t = \mu + \phi(h_{t-1} - \mu + \varepsilon_t^h), \text{ where } \varepsilon_t^h \sim N(0, \sigma^2) \quad (2)$$

$$\gamma_t = \gamma_{t-1} + \varepsilon_t^y, \text{ where } \varepsilon_t^y \sim N(0, \Omega) \quad (3)$$

where y_t is the output growth at time t , β_t is a vector of the TVPs for the constant term, and h_t is the conditional variance. The coefficient α_t captures the time-varying effect of volatility on output growth, Ω is a 2×2 covariance matrix, and the error terms ε_t^y and ε_t^h are assumed to be serially and mutually uncorrelated. The conditional variance function is specified in logarithmic form, in which h_t follows a stationary AR(1) process with $|\phi| < 1$, where $h_1 \sim N(\mu, \sigma^2/(1 - \phi^2))$. Equation (3) evolves a first-order random-walk process with a vector of coefficients $\gamma_t = (\alpha_t, \beta_t)$, starting with $\gamma_1 \sim N(\gamma_0, \Omega_0)$ for the constant matrices γ_0 and Ω_0 . The random-walk specification makes the model more flexible and enables us to capture both temporary and permanent shifts.

Equations (1) and (3) specify a nonlinear Gaussian state-space model. Because of the intractability of the likelihood function in Equations (1)–(3), the traditional Maximum Likelihood (ML) approaches cannot give strongly reliable estimates for the parameters. Chan (2017) estimates the Markov Chain Monte Carlo (MCMC) method based on band- and sparse-matrix algorithms instead of on Kalman filters. Therefore, the specification reduces the dimension of the problem and makes the estimation easier to converge. In addition to the band- and sparse-matrix algorithms, following Chan (2017), we adopt a Bayesian approach to simulate the joint posterior distribution. Therefore, MCMC is an efficient sampling approach that can simulate each type of state individually, as it exploits the

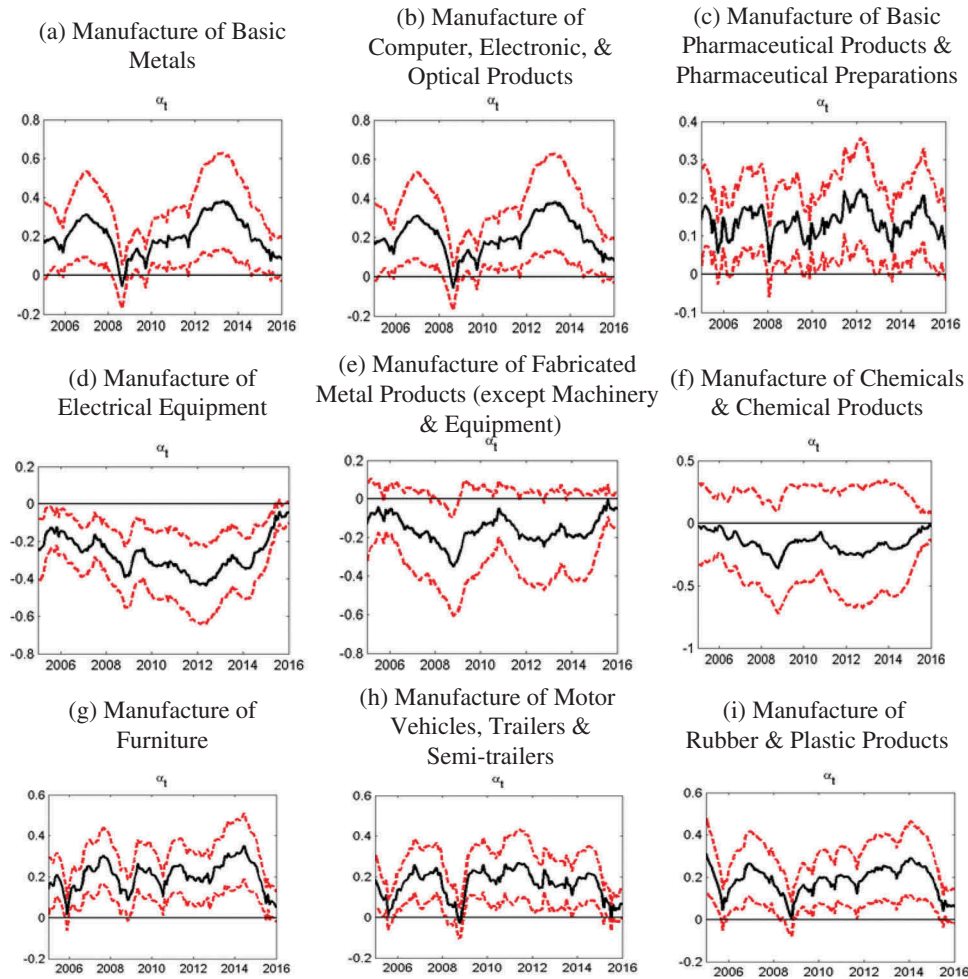


Figure 2. Disaggregate level for the period 1986:01 to 2016:01.

Note: The solid line is the estimation and the dashed lines are the 10% confidence band.

fact that the Hessian of the log-conditional density of the log-volatilities is a band matrix containing only a few nonzero elements arranged along a diagonal band (see Chan 2017 for further information).

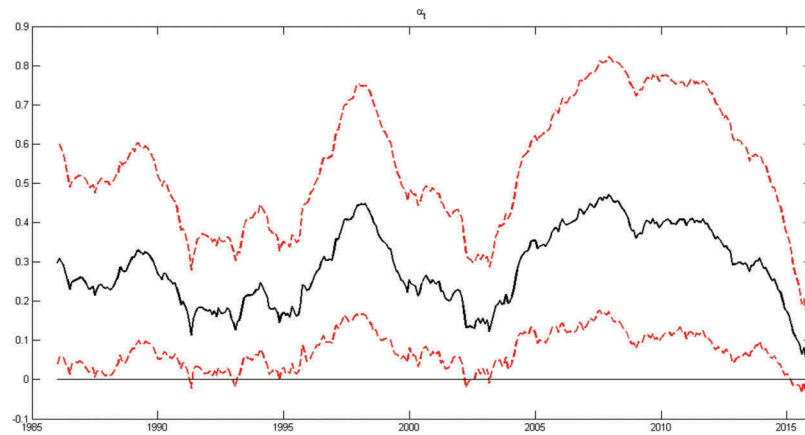
IV. Empirical evidence

Turkey is an emerging country. Thus, one may expect a negative impact of output growth volatility on output growth, as suggested by Keynes (1936) and Pindyck (1991), similar to the empirical studies of Ramey and Ramey (1995), Hakura (2007), and Berument, Dincer, and Mustafaoglu (2012). To determine whether the employed series are covariance stationary, as a necessary condition we perform unit root tests. The Augmented Dickey–Fuller and Phillips–Perron unit root tests

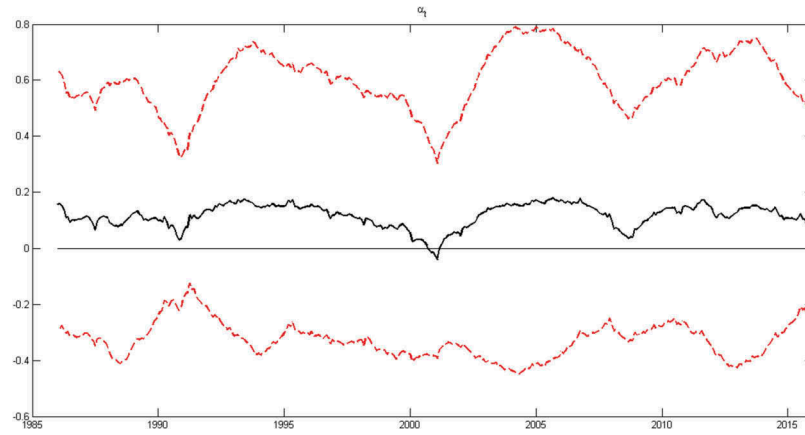
suggest that all the series are difference stationary at the 1% significance level. Hence, TVP-SVM is admissible. We perform the analyses with the aggregate output (IP) series first. Figure 1. A plots the aggregate output growth series, and suggests it has high volatility. The series reaches its peak during crises periods in 1994, 2001, and 2008. Figure 1(b) exhibits the conditional variance estimates of aggregate output growth, which are for the measure of volatility (h_t) with 90% confidence intervals. The middle line is the estimate of the conditional variances; the other two lines are the 90% confidence intervals. Figure 1(b) suggests that these estimates are statistically significant and have a value from 2.5 to 4.5.

Sharp increases in volatility are indicators of economic or financial problems. In the sample, the highest volatility period is from 1992 to 1995.

(a) Mining & Quarrying growth volatility impact on Mining & Quarrying growth (α_t)



(b) Electricity & Gas growth volatility impact on Electricity & Gas growth (α_t)



(c) Manufacturing growth volatility impact on Manufacturing growth (α_t)

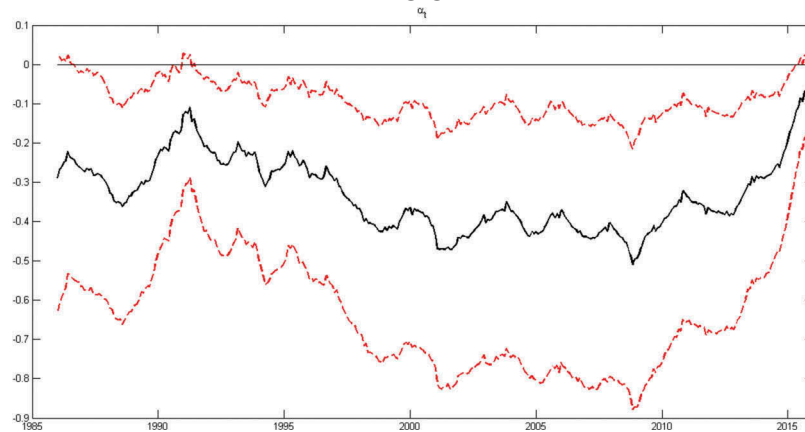


Figure 3. Sub-sectors of Manufacturing: growth volatility impact on their growth (α_t) for the period 2005:01 to 2016:01.

Note: The solid line is the estimation and the dashed lines are the 10% confidence band.

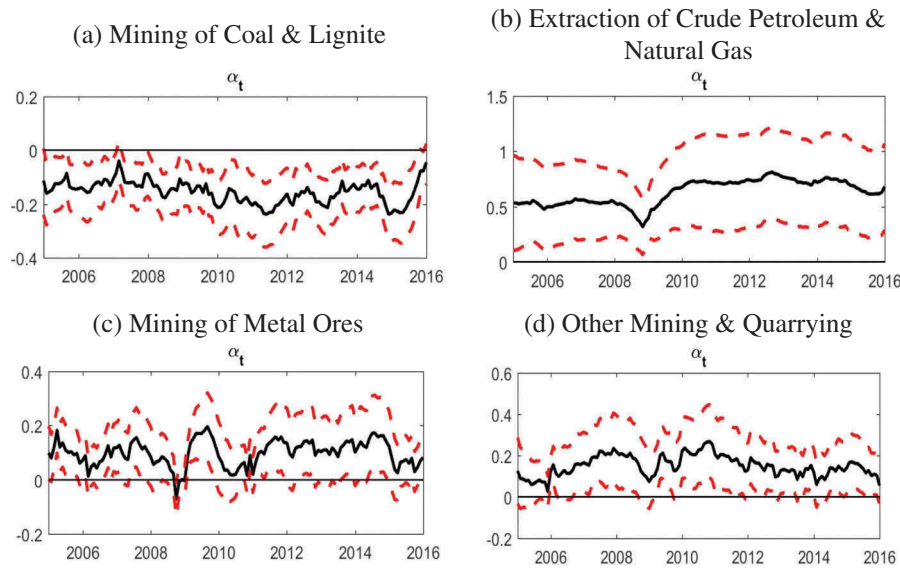


Figure 4. Sub-sectors of Mining & Quarrying: growth volatility impact on their growth (α_t) for the period 2005:01 to 2016:01.

Note: The solid line is the estimation and the dashed lines are the 10% confidence band.

Sharp increases are also observed in 2001 and 2008, and can be related to the April 1994 and November 2000–February 2001 economic crises and the 2008–2009 global crisis. Figure 1(c) plots for the time-varying effect of aggregate output growth volatility on aggregate output growth (α_t). The estimates are statistically significant and are negative in all periods. The lowest effect is in 1992, and the highest effects are in 2001 and 2009. The sharp changes in volatility (i.e. economic crises) are relevant to the impact of aggregate output growth volatility.

We repeat the analysis for the disaggregate level by using the three main sectors of IP. Figure 3(a) reports the time-varying impact (α_t) of Mining & Quarrying growth volatility on this sector's growth, in which this series has a 6.05% weight in IP. The estimated parameters are always positive and mostly statistically significant. To save space, we do not report the growth series of IP's three sectors, the four sub-sectors of Mining & Quarrying, the nine sub-sectors of Manufacturing output, or their volatility measures. These results are available from the authors upon request.

Figure 3(b) reports growth and its volatility relationship for Electricity & Gas production growth, which has a 12.44% weight in IP. The

relationship is positive in all periods except for a brief negative period in 2001. However, this coefficient is not statistically significant for the whole period that we consider. Figure 3(c) is for Manufacturing growth, which has 81.51% weight in IP. Owing to this high weight of Manufacturing, similar behaviour is expected for the total IP series. Indeed, this is the case: the estimated parameters are statistically significant and negative for all periods that we consider. Both aggregate output (IP) and the Manufacturing sector show similar behaviour.

Next, we repeat the analyses for the four sub-sectors of Mining & Quarrying. This relationship is always negative and almost always statistically significant for Mining of Coal & Lignite. The relationship is always positive for Extraction of Crude Petroleum & Natural Gas and Other Mining & Quarrying, and mostly positive for Mining of Metal Ores. The positive relationship is always statistically significant for the Extraction of Crude Petroleum & Natural Gas and usually statistically significant for Mining of Metal Ores and Other Mining & Quarrying. Last, we repeat the analysis at the sectoral level by using the nine selected Manufacturing sub-sectors. Figure 2 reports the estimates for these sub-sectors. Similar to

the whole IP, a negative relationship is observed only for three out of the nine sub-sectors. The estimates are not statistically significant for two sub-sectors in the period we consider; however, a positive relationship is observed for six of the nine sub-sectors, and the findings are mostly statistically significant for the majority of periods. Thus, we can safely conclude that while the relationships are different for all the IP series and its sub-sectors, the sign of the relationship for all the variables we consider changes little across time.

These results spark the following question: ‘What determines the sign/magnitude of the relationship between output growth volatility and output growth?’ Possible reasons for cross-sectoral differences in the sign/magnitude of this relationship might be differences in financial dependence, Research & Development spending, and the degree of vertical integration. Unfortunately, these data are not available across sectors for Turkey so this line of research could not be pursued. However, in a future work, we plan to perform the analysis across countries and identify possible reasons for the difference in the sign/magnitude of output growth volatility–output growth relationship.

A positive versus negative relationship between output growth and output growth volatility is important for its policy implications. In sectors where the relationship is positive, government should be allowing the output level to fluctuate in that sector’s production and/or make entries into and exits from the sector easier. Policies to affect price and output should not be often employed. Moreover, government could encourage firms to invest longer term in areas that are subject to uncertainty but that have high potential to generate improvement in technology through innovation, rather than touting short-term projects that may have a lower level of productivity increases. On the other hand, sustaining a certain level of production and decreasing output volatility are important in maintaining a high level of growth for sectors with a negative relationship between output growth and output growth volatility. Making tax and subsidy policies and legal frameworks more predictable and credible, as well as using these fiscal tools to stabilize sector

outputs by restraining fiscal institutions’ involvement, might be advisable for these sectors.

V. Conclusion

We analyse the effect of output growth volatility on output growth for the period 1986 to 2016 for an emerging economy: Turkey. This effect is negative and statistically significant for total IP for the period that we consider. When we investigate this relationship for IP’s three main sectors, the sign of the relationship changes across the sectors. It is positive and statistically significant for Mining & Quarrying, positive and statistically insignificant for Electricity & Gas, and, similar to total IP, negative and statistically significant for Manufacturing. We look further into this relationship for Mining & Quarrying’s four sub-sectors and nine selected sub-sectors in Manufacturing. In this deeper exploration, we also observe alternating signs for the effect of output growth volatility on output growth for these sub-sectors. Similar to Imbs (2007), this article reports a different effect of output growth volatility on output data at a different aggregation. However, Imbs finds a different relationship across countries versus across sectors; we find this different effect on total IP versus its sectors, as well as on a major sector and its sub-sectors.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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Table A.1: Data Sources

Variable	Definition	CBRT Code	Source
Aggregate Output			
Industrial Production ^a	Industrial Production (2010 = 100) 1986/01–2000/04 2000/05–2004/12 2005/01–2016/01	TP.UR4.U01 TP.TSY01 TP.N2SY01	CBRT, EDDS
Aggregate Output Sub-sectors			
Mining & Quarrying ^a	Base year (2010 = 100) ^a 1986/01–2000/04 2000/05–2004/12 2005/01–2016/01	TP.UR4.U02 TP.TSY02 TP.N2SY07	CBRT, EDDS
Electricity & Gas ^a	Base year (2010 = 100) ^a 1986/01–2000/04 2000/05–2004/12 2005/01–2016/01	TP.UR4.U17 TP.TSY30 TP.N2SY37	CBRT, EDDS
Manufacturing ^a	Base year (2010 = 100) ^a 1986/01–2000/04 2000/05–2004/12 2005/01–2016/01	TP.UR4.U07 TP.TSY07 TP.N2SY12	CBRT, EDDS
Selected Sub-sectors of Manufacturing			
Manufacture of Basic Metals	Base year (2010 = 100) 2005/01–2016/01	TP.N2SY27	CBRT, EDDS
Manufacture of Computer, Electronic & Optical Products	Base year (2010 = 100) 2005/01–2016/01	TP.N2SY29	CBRT, EDDS
Manufacture of Basic Pharmaceutical Products & Pharmaceutical Preparations	Base year (2010 = 100) 2005/01–2016/01	TP.N2SY24	CBRT, EDDS
Manufacture of Electrical Equipment Products (except Machinery & Equipment)	Base year (2010 = 100) 2005/01–2016/01	TP.N2SY30	CBRT, EDDS
Manufacture of Fabricated Metal Products (except Machinery & Equipment)	Base year (2010 = 100) 2005/01–2016/01	TP.N2SY28	CBRT, EDDS
Manufacture of Chemicals & Chemical Products	Base year (2010 = 100) 2005/01–2016/01	TP.N2SY23	CBRT, EDDS
Manufacture of Furniture	Base year (2010 = 100) 2005/01–2016/01	TP.N2SY34	CBRT, EDDS
Manufacture of Motor Vehicles, Trailers & Semi-trailers	Base year (2010 = 100) 2005/01–2016/01	TP.N2SY32	CBRT, EDDS
Manufacture of Rubber & Plastic Products	Base year (2010 = 100T) 2005/01–2016/01	TP.N2SY25	CBRT, EDDS
Mining & Quarrying			
Mining of Coal & Lignite	Base year (2010 = 100) 2005/01–2016/01	TP.N2SY08	CBRT, EDDS
Extraction of Crude Petroleum & Natural Gas	Base year (2010 = 100) 2005/01–2016/01	TP.N2SY09	CBRT, EDDS
Mining of Metal Ores	Base year (2010 = 100) 2005/01–2016/01	TP.N2SY10	CBRT, EDDS
Other Mining & Quarrying	Base year (2010 = 100) 2005/01–2016/01	TP.N2SY11	CBRT, EDDS

Notes: Abbreviations and their meanings: CBRT: Central Bank of the Republic of Turkey; EDDS: Electronic Data Delivery System.
^a A Combination of the given series is used for the entire period.