EFFECT OF INTELLECTUAL PROPERTY RIGHTS REGIME TIGHTENING ON ECONOMIC PERFORMANCE: THE CASE OF INDIA

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Abstract

Effect of Intellectual Property Rights (IPR) on developing economies is of high importance today. In this thesis it is argued that a tighter IPR protection leads to an increase in industry productivity. Two Vector autoregression models are constructed to examine the effect of the Patents (Amendment) Acts introduced in India in 1999, 2003 and 2005 on the index of industry productivity across 15 industries. The main model captures the effect of IPR protection on FDI inflows and on industry productivity, while the alternative model uses portfolio investments instead of FDI. Both the main and the alternative models are poorly confirmed, while the effect of FDI and innovative activity on industry's productivity is strong in both cases.

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Introduction

In mid 1991, following the Gulf war and collapse of the USSR, India's government ran a reform package as a measure to fight an economic crisis. The collapse of the Soviet economy (India's major trade partner at that time), and at the same time the Chinese economy becoming more market oriented, can be seen as the main factors which initiated these reforms (R. Nagaraj, 1997). Anup Tikku (1998) concludes that the reforms had mostly a positive effect: return to the pre-crisis growth rates; improvement of fiscal balance; increased borrowing for consumption; improved investment ratio and recovered growth of manufacture, though still below the pre-reform level. India, on the other hand, has long been attracting foreign investors by its relatively cheap and educated labor, reserves of raw materials and large market size. Lieten (1999) argues, that natural resources and favorable economic environment are the main factors attracting foreign investors, however cheap labor is not. Liberalizing economic reforms of the early 1990s aimed at developing such an environment. Those reforms played a significant role in opening Indian markets, spurring the economy and, eventually, attracting such an important investor as the United States. All those factors resulted in over tenfold FDI increase and its diversification (Anup Tikku, 1998 and Kumar, 1998).

Inspired by such results, the Indian Planning Commission in its 10th Plan aimed to achieve an 8-10% growth rate for the first decade of 2000 (Narendra Jhaveri, 2003). The commission, even though concentrating on economic aspects of achieving the growth target, also emphasized that only capital and resource mobilization would not be enough in achieving a significant economic growth:

> At an aggregate level, any acceleration in growth requires some combination of an increase in gross domestic fixed capital formation and an increase in efficiency of resource use. The latter requires policies, which will increase the productivity of existing resources as well as

> the efficiency of new investment. There can be little doubt that India cannot hope to achieve an 8 per cent growth, relying entirely, or even largely, on increased investment… This means that if the entire acceleration in growth has to come from additional investment with an ICOR of 4.0, it would be necessary to increase the investment ratio by 4.5 and 5 percentage points of GDP, which would have to be mobilized through additional domestic savings. An increase of this order in the average rate of domestic savings over the next five years may not be feasible. A substantial part of the additional growth must, therefore, come from increased efficiency and tapping hidden potentialities in the economy. (Planning Commission, 10th plan, 2001).

The idea of the impossibility of continuous economic growth by means of accumulation of capital only, was raised by Krugman in "The Myth of Asia's Miracle" (1994). The author discusses the case of developing Asian economies, concluding that accumulation of human and capital factors was the main reason of rapidly growing economies. Taking into account "Perspiration theory[1]" the author emphasizes a limitation of economic factors (such as financial, physical, human and knowledge resources) in achieving sustainable economic growth, due to the effect of diminishing returns. In his view, adopting advanced technology is an appropriate way in achieving stable growth rate.

India, however, has long been reluctant to adopt world's practices in promoting the inflow of advanced technologies to the country, arguing that it would have a negative effect on employment and local manufacturing (Lieten, 1999), as well as it would decrease the technology spillovers from industrial countries (Kumar, 2003). According to Nagesh Kumar (1998), Indian government restricted FDI inflows into technology-intensive industries prior to 1990, which resulted in share of services investment as of 5% only.

Experiencing pressure from industrial partners and a necessity of adoption of efficiency enhancing policies as well as institutional arrangements for the inflow of advanced technologies (Anup Tikku, 1998), The President of India promulgated the Patents (Amendment) Ordinance on the December 31, 1994 (WTO Annual Report, 1998). In August 1996 the Minister of Industry announced full compliance of Indian patent system to WTO

[1] Krugman by perspiration names economic growth caused by mobilization of resources – increase in rate of employment, level of education, physical capital, i.e. through increase in inputs, rather than through an increase in efficiency.

Agreement till the January 1, 2005. That process was, on the other hand, spread in time and it took several years and three Patents (Amendment) Acts (1999, 2003 and 2005) for India to fully comply with TRIPS[2] agreement.

The effect of Intellectual Property Rights[3] (IPR) protection on economic performance was studied in depth by many researchers. Existing theoretical models were developed, among others, by authors like Helpman (1993), Deardorf (1992) and Grossman and Lai (2004). There is also extensive empirical literature on this topic. The transitional period to stronger IPR protection regime in India was, however, omitted in this literature. For this reason, and due to the lack of agreement in theoretical works on the effect of IPR regime on macroeconomic performance, an empirical research on the effects of this shift is of high importance for policymakers in India as well as in other developing countries. Moreover, due to the lack of a uniform agreement on the effect of IPR on economic performance, a case-by-case study is necessary to take into account specificities of a particular country or region. For these reasons, I concentrate in my thesis on the case of India, rather than examining a cross-country model.

This work aims to answer whether the compliance to TRIPS by the Indian government gave sufficient incentives to foreign investors to consider India as a potentially attractive destination for investments, and whether those investments have led to a higher economic performance. The hypothesis is that change in IPR regime in India has led to increase in technology transfer into technology-intensive sectors by foreign investors, which has consequently led to increase in industry productivity. To check the hypothesis, Vector Autoregression model will be used.

[2] The WTO's Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS). It was negotiated in the 1986-94 Uruguay Round and aimed to narrow the gaps in protection of intellectual property rights around the world and to establish minimum levels of protection.

[3] "Intellectual property rights (IPR) are legal entitlements granted by governments within their respective sovereignties that provide patent, trademark, and copyright owners the exclusive right to exploit their intellectual property (IP) for a certain period. The basic rationale for IPR protection is to provide an incentive for innovation by granting IP owners an opportunity to recover their costs of research and development." (Chatterjee et al., 2008)

The thesis is structured as follows. In the first chapter the model is introduced, previous researches in the area and expected results are discussed. Data description, methodology and econometric estimates follow in the second, third and fourth chapters, accordingly. Finally, the effects of the transitional period on economic performance together with explanations and propositions for policymakers and further research follow in the conclusions.

1. Model

This thesis is based, among other theoretical and empirical studies, on the works of Helpman (1993), Krugman (1994), Kanwar and Evenson (2003) and Grossman and Lai (2004). These authors agree that increase in transfer of production, followed by transfer and spillovers of technologies to the "South", is an appropriate way in raising productivity growth. On the other hand, this research is also actively based on conclusions of Kumar (1998, 2003) that tighter IPR regime can increase industry productivity of a developing country, resulting in higher growth.

1.1. Patents protection and innovative activity

Existing theoretical literature, unfortunately, does not have a clear agreement on the effect of IPR protection on economic growth. Proponents of a tight IPR protection argue, that it provides a necessary protection mechanism for inventors to recover expenses connected with inventing activity, thereby consequently providing incentives to innovate. Innovative activity, in turn, leads to progress and increases welfare. At the same time, IPR protection tightening has the opposite effect of suppressing domestic industry relying on imitation of foreign goods and technologies and it is arguable whether the welfare increase surpasses negative effect on domestic industry relying on imitation. Moreover, the distribution of a change of welfare, caused by IPR regime change, is also unclear.

To examine the hypothesis proposed earlier, first of all the relationship between IPR protection and economic performance is decomposed into two components. The first component is the effect of IPR protection on innovative activity. The second component is the effect of innovative activity on economic growth. Further, as Falvey et al. (2006) and Tikku (1998) conclude, positive and significant correlation between IPR protection and economic growth in developing countries works through FDI from developed countries. I, consequently, use amount of FDI inflows, concurrently with the number of patents applications as an indicator of innovative activity.

There are two opposite points of view on the first component. Proponents of IPR regime tightening argue that strong protection stimulates innovation at least in technology-intensive industries, like pharmaceuticals and chemicals (Mansfield, 1986 and Levin et al. 1987). Mansfield's survey results indicate that some 60% of inventions in the chemical industry would not have been made if there was no appropriate IPR protection system (Mansfield, 1986). Taylor (1994) supports the authors, by saying that strong patent protection is not only necessary for inventive activities to be implemented on the developed North, but also weak protection on the South can divert the North from exporting technologies (by possibility of copying and imitating) and reduce research and development (R&D) activity. Another argument, supported by Mansfield (1985), is that profits of an inventor start decreasing fairly quickly due to the competition and information leak, even with some degree of IPR protection. Hence, tight IPR protection is necessary to encourage producers to undertake innovative activity. Lai (1998) concludes, that stronger protection in less developed regions increases innovative activity in developed regions in case if production can be reallocated by means of FDI. Finally, Grossman and Lai (2004) conclude, that stronger IPR protection maximizes welfare in countries with sufficiently large market for innovative products and strong human capital endowment. The authors, though, conclude that harmonization of IPR regime is not necessary and potentially harms the South.

Arguments favoring weaker protection are strongly supported as well. The most frequent one is that for developing countries, unable to devote serious expenses to innovative activity on their own, imitation serves a cheap access to technologies. The process of imitation, moreover, provides incentives to innovation, necessary for the adoption of new technology (Kanwar and Evenson, 2003). The possibility to imitate foreign goods and technologies provides significant gains to society, especially in case of drugs and medicines, which are provided by Northern producers at unaffordably high prices. Further, Bessen and Maskin (2000) show that strong IPR protection can actually slow down innovative activity. They provide an example of sequential innovations, which can be met in software industry, when a producer artificially slows down patenting activity while enjoying profits from existing products. This point can be emphasized by existence of patent tickets and patenting around[4], as in Shapiro (2001). As he concludes, the current patent system creates possibility for patent thickets, which result in significant transaction costs for producers seeking to commercialize new technologies and products, eventually discouraging or even blocking access to innovations for society and innovative activity in general. In his model Helpman (1993) presents interaction of an industrial North and less developed South and examines the effect of IPR regime change through different channels. He concludes that, even though it is possible for the North to be better off after IPR tightening, the less developed South is always worse off. Even with the use of FDI short term increase in rate of innovation will bring less improvement than long term losses. Deardorff (1992) and Grossman and Helpman (1991) reach a similar conclusion, arguing that IPR regime tightening slows down innovative process.

Summarizing the existing literature on intellectual property rights, it is clear that under broad conditions the North is better off from tightening of IPR protection. The effect on the South, however, is not that straightforward and requires, in addition to theoretical, strong empirical examination.

[4] As the author states patent thickets is a system of overlapping patent rights which makes it necessary to obtain licenses from multiple patentees for a person to commercialize technology. Even though there are methods to cut through a patent thicket, namely cross licenses and patent pools, they all involve transaction costs.

1.2. Innovative activity and economic growth

Correlation between IPR protection and innovation is, though, only the first step. What needs to be analyzed further is the correlation between innovative activity and economic growth. As Kanwar and Evenson (2003) point out, lack of correlation between strength of IPR protection and economic growth can send the false signal of uselessness of IPR protection in promoting economic growth. The reason, though, can be in a weak correlation either between IPR protection and innovative activity, or between innovative activity and economic growth.

Following the conclusions of Favley et al. (2004), I incorporate an effect of IPR protection on FDI in my thesis[5]. FDI, undertaken by multinational enterprises (MNE) in developing economies, serves as a necessary step in achieving higher economic growth rate and should be considered as a transfer of capital and technology assets, rather than a transfer of finances (Maskus, 1997). For India, as a developing country being unable to undertake serious expenses on innovation production, transfer by foreign investors is an appropriate way in accumulating technologies. Here, as Kumar (1998) and Maskus and Penubarti (1995) argue, IPR protection plays a significant role. Following the authors' terminology, the investment inflow to India can be called vertical rather than horizontal FDI, due to export and cost reduction orientation. One more reason to use FDI flows is that for a developing economy with poor IPR protection enforcement of, for example, arm's-length licensing[6] is more costly than technology transfer within the same company, as in case of FDI. Due to transaction costs (in this case writing and enforcing of a contract), information imperfections and leak, an inventor firm would be reluctant to reveal the technology or product to another firm even though constrained by conditions of a license. However, with improvement of IPR

[5] The authors state that positive relationship between IPR protection and economic growth in low income countries caused, most likely, by increase in FDI inflow from developed economies without (or surpassing) a diverse effect on a domestic industry relying on imitation.
[6] Arm's-length licensing here refers to a licensing by a mother company to its foreign subsidiary.

protection regime the costs of enforcement fall and shift from FDI to arm's-length licensing takes place. At this point it can be concluded, that IPR is negatively correlated with FDI flow after some threshold (Maskus and Penubarti, 1995).

IPR, obviously, are not the only reasons affecting the decision to invest in a country, but are its important component together with level of a market liberalization, natural resources capacity, input costs, regulations and legal enforcements, trade policies and production incentives. Another argument is that firms with a hard-to-imitate technology and production (machinery or heavy industry for example) would pay relatively less attention to IPR protection. At the same time firms with technology and products easy-to-imitate (chemicals and food for example) would pay much more attention to IPR and its enforcement. Though, technological progress has made imitation much easier in particular areas and importance of IPR has risen across industries (Maskus, 1997).

Finally, I incorporate the Krugman's theory in the second component of the relationship and use the extended model of Helpman, which allows for FDI, to examine the effect of IPR regime on industry productivity. By doing this, I aim to examine whether strengthening of the property rights protection spurred productivity growth across industries in India. I expect, following conclusions of Taylor (1994) and Maskus (1997), that shift in IPR protection regime, followed by growth in FDI in technology-intensive and at the same time piracy-vulnerable industries (such as chemicals, food and medicines), leads to growth in productivity in the corresponding industries. The effect of FDI on other industries, though expressed to a less extent, can not be undermined due to the rising importance and intensity of R&D across all industries. I also found that a large amount of empirical work has been done by means of cross-section and panel regressions. There is a problem of causation at the same time. Kumar (2003), for example, states that "the level of development is likely to be a determinant for strength of IPR regime rather than the other way around". Another argument is that change in IPR protection regime is a discrete process, especially in the case of India. Discrete nature of the process will, most likely, result in shocks to macroeconomic variables. Summarizing all the above, I conclude that the VAR model is an appropriate approach for empirical estimation of the changes in IPR regime in India on industry productivity.

1.3. Alternative model

An alternative model using data on portfolio investment instead of FDI will be tested as well. It is based on works of authors integrating money supply into economic growth models. The concept originates from the substantially extended and modified works of Tobin (1965), Davidson (1968) and Sidrauski (1967), among others, where the authors analyzed the effect of money supply on economic activity. However, these studies had conflicting conclusions. Davidson in his work emphasized the necessity of initial fund for capital accumulation and consequently growth. Sidrauski argued, that the use of the money stock in raising the capital stock could actually lead to a decline in the latter and different mechanisms might be considered for that purpose. Gauger (1988) examined the money neutrality hypothesis on a disaggregated level of eleven US industries. He concluded that the result was dependent on the specification of money and the neutrality hypothesis was rejected for two out of three specifications in his model. Finally, Durham (2003) examined the effect of other than direct foreign investment on economic growth using data on 88 countries. He emphasized lack of empirical research applying other than direct investment, conversely to the increasing amount and significance of those types of investment. His work resulted in portfolio and other than direct types of foreign investments being significant in six estimates out of sixty. Durham mentioned that the market size and corruption ratings were the factors that possibly diminished the effect of investments on growth. The author also mentioned that some empirical works found a negative effect of a portfolio investment on economic growth and emphasized a possibility of simultaneity bias in his model. This fact also favors the use of a VAR model here.

This model will capture the same IPR protection-induced investment to the Indian economy, together with an alternative mechanism of a money supply-induced growth and this model will incorporate the data on investment, which includes such main component as portfolio investment. My expectation is that investment shocks have significant impact on the index of industry productivity in India. However, these effects can very well vary over the sectors, influenced by differences in corruption level, absorptive capacity and market size, and other less important factors.

2. VAR methodology

VAR model can be viewed as a system of *n* variables. In such system each endogenous variable is regressed on its own lagged values and the lagged values of the rest *(n-1)* variables in the system (Stock, Watson, 2001). A VAR system can be represented by:

$$y_t = A_1 y_{t-1} + \dots + A_p y_{t-p} + Bx_t + \varepsilon_t$$

where y_t is a k-dimensional vector of endogenous variables, x_t is a d-dimensional vector of exogenous variables, As and Bs are matrices of coefficients to be estimated and ε_t is a vector of unobservables. The unobservables can be contemporaneously correlated, but are uncorrelated with their own lagged values and the right-hand side variables. VAR model solves issue of simultaneity by using lagged variables as regressors.

As argued by Sims (1980) and Stock and Watson, VAR methodology provides a credible approach for data description, forecasting, structural inference and policy analysis. Rich VAR methodology is represented in three forms: reduced, recursive and structural VARs. Reduced form VAR represents variable as a function of its own lagged values and lagged values of all other variables in the system plus a serially uncorrelated error term. The assumption of serially uncorrelated residuals, however, is strong and a reduced form VAR can be used in either simplified or specific model. Recursive VAR, in turn, solves the issue of serially correlated residuals, appearing in reduced form VARs. This is done by arranging the error covariance matrix is such a way, that a shock to the first variable contemporaneously affects all the other variables and is not affected by anything else; a shock to the second variable affects all the other variables contemporaneously except the first one, and so on. Often reduced and recursive form VARs are generalized as non-restricted VARs. Finally, structural VAR uses economic theory to impose assumptions on contemporaneous correlations between variables. There are several instruments used when a VAR model is estimated to examine it. These are Granger-causality test, impulse response functions and variance decomposition. These instruments are more informative than estimated coefficients or even R^2 statistics.

The Granger-causality test examines whether lagged values of a variable or variables help to predict changes in another variable. A variable is said to Granger cause another variable if the former helps in prediction of the latter. 1% and 5% thresholds are typically utilized in testing the null hypothesis of no Granger causality.

The Impulse response function traces the transmittion of a shock to variable on other variables through the dynamic lag structure of the VAR. Typically impulse response functions are calculated for recursive and structural VARs.

Finally, variance decomposition separates variation in a variable into component random innovations[7]. Applying described methodology to the model, I will be interested in the results of the Granger causality tests, particularly in the effect of number of patents applications on FDI and level of FDI on the index of industry productivity. The results of the impulse response functions are of a high interest too, particularly the responses to a shock to patents applications and a shock to FDI.

I expect that The Patents (Amendment) Acts introduced by the Indian government in 1999, 2003 and 2005 initiated positive shocks to the patent applications on the territory of India. Those shocks, further, caused positive shifts in industry productivity either directly or through a rise in FDI and investments. The instruments of VAR modeling, described above, will help to trace the effects on FDI inflows and on the level of industry productivity.

[7] Descriptions of the Granger-causality test, impulse response function and variance decomposition are taken from the User’s guide for Eviews 5 program.

3. Data

VAR model consisting of three variables will be estimated to examine whether the TRIPS compliance by India's government was a meaningful step in enhancing productivity growth. The variables represent number of patent applications on the territory of India, foreign direct investment (FDI) inflow (portfolio investment inflow in the alternative model) and disaggregated index of industrial productivity (IIP) on fifteen industries. The data are of monthly frequency and were collected from web pages of the Indian Reserve Bank (RBI) and the World Intellectual Property Organization (WIPO)[8].

The data sample covers the transition period in India during which three patents amendment acts had been introduced. It starts with observations from 1999, when reliable data on patent applications began to be available. According to the information from the Office of Controller General of Patents, Designs and Trademarks[9], the date when the first Patents (Amendment) Act was introduced[10] is 26 March 1999. An exogenous dummy variable *act_1999* becomes unity from the April 1999 to take this fact into account in the model. This Act provided for filling applications for product patents (instead of patents for processes) in areas of pharmaceuticals, drugs and agro chemicals. Applications for patents in these areas, however, were to be examined only starting from 1 January 2005. Meanwhile inventor could apply for exclusive marketing rights to sell and distribute his product on the territory of India. The next Act was made on 25 June 2002, though it came into force only on 20 May 2003, and introduced new Patent Rules instead of those existing from 1972. According to these rules the length of patent protection increased to 20 years, the definition of patent was changed, an eighteen month period before publishing of patent was introduced and, basically, significant

[8] Web pages of the Indian Reserve Bank and the World Intellectual Property Organization are www.rbi.org.in and www.wipo.int correspondingly.
[9] Web page of the Office of Controller General of Patents, Designs and Trademarks is http://ipindia.nic.in/ipr/patent/patents.htm)
[10] Here, the first out of the three acts considered.

shift in patents rules towards the existing in industrialized world occurred (Controller General of Patents, Designs and trademarks[11]). The last Patents (Amendment) Act considered in this work came into force from 31 December 2004. It allowed for patents in such industries as pharmaceutics and software.

The number of patent applications is a variable indicating innovative activity and, hence, largely sensitive to the IPP regime in a country. Based on the data from the WIPO, one can conclude that until the late 1990s the number of patent applications on the territory of India was very low, with monthly average for 1999 of 8.4 applications. The data exhibits an upward trend and in 2001 and 2003 the average number of applications already equals 18.9 and 39.5 respectively. Patent applications used here are applications, filed in accordance to the Patent Cooperation Treaty (PCT). This is an international treaty administered by the WIPO, brought forward to simplify the process of multi-national patent filings, while enabling to seek patent protection in a number of countries. The PCT applications, nonetheless, do not result in provision of "international patent" (WIPO). The number of patent applications, except serving to reflect the correlation of IPR protection regime with FDI inflows to India, will reflect the direct effect of innovative activity on industry productivity. This variable, serving as a proxy for IPR protection regime, has however one drawback. Frequency of patent applications depends on a number of variables – from macroeconomic to policy variables and risk factors – and is relatively high. IPR protection regime, meanwhile, changes relatively rarely – four times in six years particularly in this model. Hence, an overall volatility of patent applications will not proportionally reflect volatility in IPR regime. Three dummy variables are used in the model as exogenous variables to overcome this issue. These dummy variables (namely *act_1999*, *act_2003* and *act_2005*) take value of "1" after the dates, when the corresponding patents amendment act came into

[11] http://www.ipindia.nic.in/ipr/patent/salient_f.htm

force. Another drawback of the patents variable is that the magnitude of shocks will be biased downwards due to the fact that not all patents are applied to industrial production and not all of them affect the index of industry productivity. The main purpose of this particular VAR model, though, is not in determining the elasticities of variables, but in detecting causalities and determining direction of a response to shocks.

Another variable is the amount of FDI inflow, which reflects investors' confidence in the India's market. FDI is an endogenous variable in the model and is affected by the changes in IPR protection regime, reflected by patent applications. In his work Tikku (1998) states that the role of IPR protection on FDI inflow is at best minor, providing figures of investment inflows to India in early 1990s. Most, however, agree on the importance of IPR protection for FDI in technology-intensive sectors. The data on FDI inflows, unfortunately, are provided in aggregated format; otherwise the results would be more sensitive and shocks would have different magnitudes, as I expect.

The last variable is the Index of Industry Productivity disaggregated in fifteen groups[12]. It reflects the growth in output for a particular industry with some year value (1994-95 in this case) taken as a base. This is an endogenous variable and is affected by both IPR regime and FDI inflows. I expect, in terms of this thesis, an increase in IPR protection to follow a positive shock in FDI, caused, in turn, by positive shock in patent applications. The industries to be affected by the shock most of all are chemical, food and, to some extent, beverages and tobacco industries. The reason why I believe these industries will be affected more than the others is close to zero marginal costs of production and, hence, high vulnerability to imitation by local producers. I expect insignificant, if any, positive correlation between change in IPR protection regime and productivity in such industries as metal, machinery, transport, petroleum and minerals industries due to significant capital costs

[12] Summary on the index of industry productivity is represented in Apendix, Table 1.

incurred and, hence, low possibility of imitation. I expect the same insignificant effect in textile, paper and cotton industries, where FDI aims at utilizing low labor costs and not progressive technologies mainly (Maskus and Penubarti, 1995 and Falvey, 2006). As, however, it has already been mentioned, possibilities for imitation rise with technological advance across all industries and IPR regime changes occurred during considered period could affect all industries. Finally, three dummy variables, namely act_1999, act_2003 and act_2005 are used to reflect the stages of changes in the IPR regime.

4. Empirical results

4.1. Initial investigation

Visual examination of Figures of the series makes it possible to conclude that series *cotton, food, jute, machin, manufact, mineral, mining, transp* and *patent* exhibit strong seasonal patterns (Appendix, Figure 1). In most of the cases it is strong positive shock at the beginning of a year. Corresponding variables consequently were seasonally adjusted using X11(Historical) module of EViews.

The next step is to examine data for presence of structural breaks. Specifically, the beginning of period of each series needs to be examined. The reason for conducting this examination in the first place is that the data will further be tested for the presence of a unit root. However, the test results can be misleading if a unit root test is applied to data containing a structural break, as Perron (1989) states. The author particularly emphasizes that standard unit root tests fail to reject the unit root hypothesis in the presence of a structural break.

Patent series does not exhibit evidence of structural breaks (Appendix, Figure 2). After seasonal adjustment, however, some excessive volatility appears at the end of the period, which doesn't cause problems when estimated (Appendix, Figure 3). Similarly, FDI does not exhibit evidence of structural breaks, though some shocks present in the middle of the period. Data on portfolio investment exhibits excessive volatility in the end of the sample but no evidence of a structural break (Appendix, Figure 4). The period with excessive volatility will, however, be cut off later.

None of the series *alloy, bever, electr*, *machin*, *manufact*, *mining*, *petro*, *textile* or *transp* exhibits evidence of structural break at the beginning of sample (Appendix, Figure 5).

Even though volatility in most of the cases increases towards the end of the period significantly, the beginning of samples shares low volatile and upward trending features.

Visual examination of series *chem* allows detecting unexplainable positive shock, lasting five months from the November 1999 till March 2000. As a result this series would be included starting from the April 2000. Series *metal* exhibits several significant positive and negative shocks at the beginning of the sample and, consequently, will be used starting from September 2000. Series *mineral*, except strong seasonal pattern, doesn't exhibit evidences of structural breaks. After seasonal adjustment, however, the beginning of the sample becomes excessively volatile. Consequently sample will be used starting from the June 2000. Series *paper* exhibits insignificant change in pattern and will be used starting from the January 2000. Series *wood* exhibits two significant negative shocks in the middle 1999 and 2002 and, consequently, will be used starting from the January 2000 (Appendix, Figure 6). Series *cotton* exhibits multiple pattern changes both pre and after seasonal adjustment, which could be caused by the climate specifics. Considering a possible structural break the series is excluded from further modeling.

Series *fibre* exhibits stable upward trending pattern until the beginning of 2003, where strong negative three-month shock affects the series. The series, however, gets back to its pattern after the shock and cutting the sample appears unnecessary. Series *food* exhibits impressively strong seasonal pattern and excessive volatility after seasonal adjustment. There is a persistent negative shock in the early 2003 which, however, should not cause biased estimations since it is situated not in the beginning of the sample. Series *jute* exhibits strong persistent volatility during the whole period, which probably caused by climate dependence, but no evidence of structural breaks (Appendix, Figure 7).

4.2. Tests for stationarity

Two tests for each series were applied to check for the unit root: Augmented Dickey-Fuller (ADF) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS). The null hypothesis for the ADF test is nonstationarity of a series, while the KPSS test utilizes an alternative null hypothesis of stationarity of a series. The tests summary is represented below in the Table 2.

Table 2. Summary of the unit root tests

Variable	Level form		First difference	
	ADF test	KPSS test	ADF test	KPSS test
alloy		***	***	*
bever		***	***	
chem		***	***	
electr		***	***	**
fibre	*	***	***	
foodsa	***	**	***	
jutesa	***		***	
machinesa		***	***	
manufactsa		***	***	*
metal	***	**	***	
mineralsa		***	***	*
miningsa		***	***	
paper		***	***	
petro		***	***	*
textile		***	***	*
transportsa		***	***	
wood		***	***	**
patentsa		***	***	
FDI	***		***	
portfolio		***	***	

, ** and * indicate results significant at 10%, 5% and 1% respectively.*

According to the results of the tests series *alloy*, *bever*, *chem*, *electr*, *fibre*, *machinsa*, *manunfactsa*, *mineralsa*, *miningsa*, *paper*, *petro*, *textile*, *transpsa*, *wood*, *portfolio* and *patentsa* contain the unit root. Further, the tests are applied to the first differences of the series. ADF test rejects the unit root in all the cases. KPSS test fails to reject the null hypothesis of stationarity in seven cases, though the test result is marginally significant.

Hence it can be concluded that most of the series are I(1), while *foodsa*, *jutesa*, *metal* and *fdi* are I(0). Failure of the KPSS test to reject stationarity of the first difference of some series can be caused by excessive volatility at the end of the observed period and is marginally significant. For conducting a VAR model all series were transformed, when required, to I(0) form.

4.3. Estimation results

I estimate a VAR model including three endogenous variables – *d(patentsa)*, *fdi* and one out of 15 indexes of industry productivity – and three exogenous variables – c, act_2003 and act_2005. The reason why there are only two time dummy variables included is that I estimate the initial model with twelve lags included, which results in some degrees of freedom lost at the beginning of the sample. Consequently the data sample does not actually cover a period earlier than the April 1999, before any of the Patents (Amendment) Acts were introduced.

An initial lag length is chosen to be 12. A yearly period is assumed to be long enough to capture the interactions between IPR protection, industry productivity and forward looking investment and to be not noisy enough to capture more contemporaneous causalities. Sample size is adjusted according to conclusions from the previous subchapter[13].

I started examination of the model with industry productivity indices of the most interest – *chem*, *bever* and *food*. In case of *chem* the lag length criteria test suggests the optimal length of 12, 11 or 1 lags. Estimating the VAR with 12 and 11 lags results in roots of characteristic polynomial inside the unit circle and no serial correlation in residuals. The Granger causality test, however, rejects causation between any of the variables. I further

[13] Test results on VAR stability, serial correlation in residuals and sample sizes are presented in the Table 3 in appendix.

reduce the lag length to 1 to capture contemporaneous relationship. This results in an evidence of autocorrelation in the residuals (these results are summarized further in Table 4, together with results for the other industries).

Models with *bever* and *food* as endogenous variables result in optimal lag lengths of 3-2-1 and 12-10-1 respectively. Estimating model with *bever* with the lag length of 3 results in stable unit roots and no serial correlation in the residuals (Appendix, Table 3). However the results of the Granger causality test reject presence of any causation (Table 4). Reducing the lag length results in residuals serially correlated. Similar results are obtained when *foodsa* variable is used.

Entries with stable roots and no serial correlation in residuals were further examined with the Granger causality test and Impulse response functions. The model with *textile* as endogenous variable results in stable VAR and no serial correlation in residuals for 4 and 7 lags included. The Granger causality test in model with 7 lags indicates unidirectional causality from the industry productivity index to the number of patent applications significant at 5%. It also detects weak, less than 10%, cumulative causation from FDI and industry productivity to the number of patent applications (Table 4). Another direction revealed by the test is cumulative causation from FDI and patents applications to the industry productivity index, significant at 1%. These results indicate partial confirmation of the model proposed earlier; FDI inflows affect industry productivity, but the number of patent applications, being a proxy for IPR protection, does not cause FDI. Impulse response function results in noisy responses of all the variables to shocks, which die out in two years at most (Figure 8). That noise makes it impossible to make clear conclusions on the effect of shocks to the variables of interest.

The model with four lags only is examined next in an attempt to reduce the noise. Granger causality test reveals significant causality at 5% from the IIP and FDI to the number of patent applications, with effect of the IIP being significant at 1%, and from the number of patent applications and FDI to the IIP, with effect of FDI being significant at 1% (Table 4). The same conclusion of the theory's partial confirmation can be made here – evidence of FDI led industry productivity is confirmed, while IPR protection has no effect on FDI inflows. Impulse response function's results are, however, not clear in this case either. Shocks to variables cause short-run volatilities only, dying out in two years at most and not allowing to distinguish long-run inferences. The summary of estimations across all industries is presented in Table 4 below.

Table 4. Summary of the Granger causality tests results.

Variable	Lags	Causality					
		FDI to IIP	patentsa to IIP	both to IIP	IIP to FDI	patentsa to FDI	both to FDI
d(alloy)	7	**	***	***			
	1				*	**	**
d(bever)	3						
d(chem)	12	*					
d(electr)	12						
d(fibre)	10		***	**			
jutesa	2		***	***			
d(machinesa)	7	**					
metal	4		***	***	*		**
d(petro)	7	***	*	**			
d(textile)	7	***	*	***			
	4	***		**			
d(transpsa)	9		***	***			

, ** and * indicate results significant at 10%, 5% and 1% respectively.*

Based on the information from Table 2 it can be concluded that the model proposed was fully confirmed in two cases only, with *alloy* and *metal* variables used as IIP. The case of *alloy* is particularly interesting because it indicates a time gap between mechanisms working in the model. The Granger test reveals significant causality at 1% from both patents applications and FDI to industry productivity, working as far as seven months back, while less strong causation from patents applications and industry productivity to FDI, working as far as 1 month back. This can imply that, for example, main foreign investors to India are able to make their decisions on FDI promptly and flexibly. Another possibility, which is more likely, is that the trigger factors of FDI, which are IPR protection and industry productivity here, are known to the investors with a large degree of precision and FDI process starts working promptly right after. The lag length of 7 months for the effect on IIP seems reasonably long, considering a time required to incorporate new investments into a production process and then for production process to affect the industry-wide Index of Industry Productivity. In case of *metal* both effects work simultaneously lagged 4 months back. While a 4 months gap to affect the FDI flow can be explained by the same reasons as above, the same period for FDI inflows and innovative activity to affect IIP of the metal industry seems to be relatively short. Another fact, concerning these two indices, is that they both represent metal industry, where *metal* represents mostly non-ferrous metals industries and *alloy* represents ferrous and alloys industries. Summarizing, the results in Table 2 support the arguments of Maskus and Penubarti (1995), Walz (1997) and Kumar (2000) that FDI is a preferred way in obtaining new technologies for India as a developing country for several industries. IPR protection, however, does not seem to be crucial in promoting FDI inflow and is significant for three industries only.

Another instrument applied for this model is the variance decomposition. Summary of the results is presented in Table 5[14]. Results presented in this table indicate relative importance of a shock to FDI in explaining the variance of IIP for such variables as *alloy*, *chem.*, *electr*, *petro* and *textile*. Effect of patents applications in explaining the variance of FDI is significantly important for *chem.*, *electr*, *fibre* and *transpsa*. Hence I find moderate support for the proposed model in case of chemical and electro industries. FDI inflows have stronger effect on IIP than local innovative activity, supporting the argument of Maskus

[14] Values in the table are presented every time for the last month of a 12-months period.

(1997) and Favley et al. (2003) about FDI being more appropriate mechanism in raising productivity than local innovations in developing countries.

Table 5. Variance decomposition

Variable	Lags	Variance decomposition (in percents)			
		FDI to IIP	patentsa to IIP	IIP to FDI	patentsa to FDI
d(alloy)	7	27	11	17	7
	1	2	7	3	4
d(bever)	3	2	5	5	6
d(chem)	12	35	13	3	19
d(electr)	12	26	18	14	32
d(fibre)	10	15	30	8	22
jutesa	2	6	13	6	7
d(machinesa)	7	16	7	17	9
metal	4	4	25	12	14
d(petro)	7	28	11	11	12
d(textile)	7	25	12	11	6
	4	8	10	9	5
d(transpsa)	9	12	19	11	20

The empirical results do not fully support the proposed model in any of the three industries of interest: FDI only causes IIP in the chemical industry, and that evidence is rather weak, too. Otherwise, the results fully confirm the model for the metal industry and alloys industry and partially confirm the model for six other industries. Particularly, FDI led productivity is confirmed for five industries and IPR led FDI is confirmed for one industry. The evidence of local innovative activity and FDI led industry productivity is much stronger than the evidence of IPR protection led FDI inflows, where the former is significant in 7 industries and the latter is significant in 3 industries only. The time gap before causation spans from one to twelve months with a peak appearing at seven lags, then decreasing at nine and four and the rest lags appearing the least. One more finding I want to emphasize is that in all three cases, when FDI is confirmed to be affected by either patents applications or industry productivity, the effect appears after a short period of one to four months. Causation from FDI and patents applications, on the other hand, takes more time to take an effect, with seven to ten months prevailing. Variance decomposition provides more favorable for the model results, especially in cases of chemical, electro and, to a less extent, fiber, oil and transport industries.

4.4. Alternative model

Considering all the results above, an alternative model will be estimated, where data on portfolio investment is used instead of FDI. This model follows the empirical works of Gauger (1988) and Durham (2003). Gauger in his work tests the null hypothesis of money neutrality on a disaggregated level of the US industries, while Durham concentrates on the effect of portfolio investment and a bank lending on economic growth.

The data sample is cut in this case until April 2004 due to unexplained high volatility in the data on portfolio investment with monthly difference reaching 2000 units. The dummy variable reflecting the Patents (Amendment) Act of 2005 is, consequently, not used here. The samples for patent applications and IIP remain according to Table 2. The number of patent applications, however, is used in form of the first difference only in cases when IIP is I(0); otherwise the level form is used, due to the fact that the data on portfolio investment for this period is I(1).

The same steps are implemented in this model: checking for the optimal lag length; checking for VAR stability; choosing the optimal lag, if necessary, and checking for remaining serial correlation; checking for Granger causality and checking the effects of shocks to the variables of interest by means of impulse response functions. Results of the first two steps are presented in Appendix, Table 6. Afterwards, entries with stable unit roots and no remaining serial correlation are checked by the Granger causality test.

Estimating the model with the variables of interest *bever* and *chem* leaves no possibility to continue examination either due to instability of VAR or due to remaining serial correlation in residuals. Estimating the model with *foodsa* as a dependent variable and 2 lags used results in a model with stable VAR and no serial correlation in residuals. The Granger causality test results in causality from portfolio investments and IIP to the number of patent applications significant at 1% and less significant causality from investments and patent applications to the IIP (Table 7). These results again only partially confirm the proposed theory: there is evidence of an investment led growth of productivity, but the causation of investment by IPR protection has not been confirmed. Impulse responses, however, provide better results than in the previously examined model (Appendix, Figure 9). In the model with 2 lags estimated, a shock to the number of patents applications causes positive shock to the industry productivity index reaching 4 units in 2 months and slowly dying out to zero in three years approximately. There is an opposite effect in force at the same time – a shock to the industry productivity index causes an increase in number of patents applications, reaching its peak of 2 in four months, which dies out in two years. There is one more effect reflected by the impulse response function, which is negative, but close to zero, response of the industry productivity index to the shock to investments.

Estimating the model with *textile* as an index of industrial productivity with 3 lags included results in stable VAR and no serial correlation remaining in the residuals. Granger causality test in significant at 1% causality from the industry productivity index and investments to the number of patent applications and from patent applications and the industry productivity index to investments (Table 7). Money supply productivity growth in this case, however, is not supported and the granger causality test finds no causation from investment to the industry productivity index. The impulse response function shows a persistent positive shift of the industry productivity index in response to a shock in patent applications that reaches 5.3 in four months and then stays at approximately 2.2-1 for two years (Appendix, Figure 10). The index responds positively, though insignificantly, to the shock in investments, resulting in a shift of 0.3-0.15 for two years.

Table 7. Summary of the Granger causality tests results, alternative model

Variable	Lags	Causality					
		portfolio to IIP	patentsa to IIP	both to IIP	IIP to portfolio	patentsa to portfolio	both to portfolio
alloy	2		*				
electr	3		**			**	
fibre	3				***		***
	2				***		***
	1		*		***		**
foodsa	2		**	**			
jutesa	3		**	***	***		***
machinesa	3		**	*			*
manufactsa	2						
	1						
metal	3		**	***			
	1						
mineralsa	1						
miningsa	2						
paper	4	***	**	***			
	1	***		***			
petro	2						
textile	3		*		***		***
wood	1						

, ** and * indicate results significant at 10%, 5% and 1% respectively.*

Results of the Granger causality tests for all IIP are presented in Table 7. From the table it can be concluded that the alternative model was fully confirmed for one out of fifteen IIPs only, which is *jutesa*. In three cases the model was confirmed partially, resulting in causation from investments and patent applications to industry productivity, namely for *foodsa*, *metal* and *paper*. In two cases, for *fibre* and *textile,* the model was confirmed partially resulting in causation from the patents applications and industry productivity to investments. Disaggregating the results into partial effects results, however, in that the number of patents applications has had significant effect on investments only once (*electr*) and the investment inflows caused significantly IIP only once (*paper*). Local innovative activity was again confirmed to be important for a productivity growth and was significant in eight cases.

Table 8 presents variance decompositions. The results indicate relative importance of a shock to portfolio investment in explaining the variance of IIP for such variables as *metal* and *paper*. Effect of patents applications in explaining the variance of portfolio investment is significantly important for *cotton* and *metal*. Overall the alternative model provides less explanatory power. In some cases (namely *manufacsa*, *metal*, *mineralsa* and *paper*) relative power of the IIP in explaining the variance of portfolio investment is zero or close to zero. One possible explanation for this finding is a forward looking and long term nature of portfolio investment. Conversely to the main model, portfolio investment has relatively less effect on the IIP than local innovative activity. This can imply that the purpose of portfolio investments was capital accumulation, rather than development of innovative technologies.

Table 8. Variance decomposition, alternative model

Variable	Lags	Variance decomposition (in percents)			
		portfolio to IIP	patentsa to IIP	IIP to portfolio	patentsa to portfolio
alloy	2	1	13	4	6
electr	3	10	33	4	10
fibre	3	8	9	16	12
	2	6	6	16	6
	1	1	8	11	1
foodsa	2	2	24	3	5
jutesa	3	9	8	13	18
machinesa	3	11	32	5	13
manufactsa	2	0	11	1	5
	1	0	9	0	1
metal	3	31	23	0	19
	1	29	2	0	8
mineralsa	1	1	21	0	4
miningsa	2	3	5	8	12
paper	4	25	32	7	10
	1	20	3	0	2
petro	2	1	10	9	3
textile	3	1	27	15	11
wood	1	9	3	0	2

The alternative model, on the other hand, provided better results when impulse response function was used. Portfolio investment positively affected the IIP when *electr*, *machinsa* and *wood* were used as the IIP. Even though responses were moderate, from 2.5 to 1, they accounted for approximately 10% of standard deviation for the period in each case. For *fiber* and *paper* the responses of the IIP to portfolio investments were negative and, in case of *fiber*, one year long only. Durham (2003) provides possible explanations to this finding; absorptive capacity and corruption are among them. Portfolio investment had little or no effect on the IIP in other industries.

Unfortunately, the other component of the model seems to have little relevance. Eight months positive shock in portfolio investment in response to a shock in patent activity appeared, when *machinsa* variable was used. Otherwise only a short-term volatility was observed. Another important finding is that a patenting activity caused long-term positive shift in the IIP in most of the industries. In some industries the shift was eight to twelve months only and in case of wood industry it was negative.

Based on the results of these two models it can be concluded that the IPR protection regime in India did not play a decisive role in attracting investments; the effect of IPR protection on investment activity was close to zero in both models. The effect of investments on the index of industry productivity was supported much stronger in the case of FDI than in the case of portfolio investment. In the case of portfolio investment, however, the impulse response functions provided more stable results. The effect of innovations on industry productivity was confirmed in seven and six cases for model using FDI and portfolio investments respectively. Finally, what can be noted is that for the first model causality from FDI to the IIP was confirmed, but not the other way around in most of the cases; in the model with portfolio investment causality from IIP to investments was confirmed and only once the other way around.

Conclusions

In this thesis I aimed to analyze the effects of the shift towards tighter regime of Intellectual Property Rights protection on the economic performance in India. Much of the empirical work on the topic of intellectual property rights concentrates on cross-sectional models, while country specific modeling, dealing with the problem of causality and allowing to examine effect of shocks to variables of interest, seems to be lacking. An empirical model was constructed and then examined by means of Vector autoregression. The effect of IPR protection on economic performance was further decomposed into two components: the effect of IPR protection on FDI inflow, which is portfolio investment in the alternative model, and the effect of FDI inflow on index of industry productivity across 15 industries.

The empirical findings of this thesis fully support the main model in two out of fifteen industries. An interesting finding is that the industries supported are metal and alloys, while I expected it to be such industries as chemicals, beverage and food, as they are theoretically the most vulnerable for imitation. Another interesting finding is that for the alloys industry two components of the proposed model (namely the effect of IPR protection on FDI and the effect of FDI on industry productivity) are supported for different lag lengths. This is of no surprise taking into account that the mechanisms of IPR protection and FDI inflows take their effect through different time periods. Examination of this model with impulse response functions resulted in no stable long-run responses to shocks for any industry. Even for the cases where the Granger causality test has confirmed causation for either of the two components of the model, impulse response function's results detected short-run responses, dying out in eight to twelve months at most.

The alternative model based on the works of Gauger (1988) and Durham (2003), who examined the money supply led growth of productivity, was used afterwards. This model has been fully confirmed for one out of fifteen industries only, namely the jute industry. For eight out of fifteen industries, however, the model was confirmed partially. Moreover, this model provided much clearer impulse response functions' results with stable responses to shocks, allowing us to make conclusions on the long-run effects.

Summarizing these findings it is natural to conclude that, while FDI inflows provided necessary improvements to industrial production in India, IPR was not the key factor causing this inflow. These results coincide with the findings of Park and Ginarte (1997) in that IPR protection separately does not positively contribute to economic growth. Moreover, their statement of insignificance of IPR protection for investment inflow in less-developed countries was confirmed as well. Furthermore, my results coincide with the findings of Maskus and Penubarti (1995) that productivity indices of the most patent-sensitive industries were unaffected by tightening of the IPR regime. The lack of correlation between IPR protection and FDI, which I found in my thesis, was also supported by Maskus and Penubarti. They explain this by shift from FDI to arm's-length licensing caused by reduction in transaction costs. Another explanation is that relative importance of FDI channel in productivity growth can be small in case of India, as mentioned by Falvey (2006).

I am aware that there are ways my research can be improved. The VAR model used in this thesis might have been overly simplified and the omitted components resulted in loose correlation between IPR and productivity. Use of quarterly data, even though reducing the preciseness of results, would provide more stable impulse responses, which would be a valuable result in the model with FDI. Relatively short period of less than ten years after introduction of the Patents (Amendment) Acts, unfortunately, doesn't allow for it. It is also possible to apply a VECM for the alternative model due to the fact that portfolio investment is I(1). That model, however, was not of the most interest in the present work. The best way to improve the results of the main model would be use of the data on FDI disaggregated across countries investors and destination industries. By doing this the precise response to innovations in the variables of interest across industries would be captured. Finally, the variable indicating level of IPR protection can be improved. Even though number of patents applications reflects an attractiveness of a local patenting system and can be calculated with necessary frequency (monthly in this case), it does not consider such aspects as enforcement, corruption and political regime, which all have effect on investment decisions. Use of advanced IPR indices, such as Ginarte-Park IPR index for example, was not possible in my thesis due to the index's lower than monthly frequency.

The issue of intellectual property rights is largely involved in almost every area of an economy. It is of a particularly high importance for developing countries, which experience the pressure of an IPR harmonization process from developed countries. The results of my thesis can help in deciding on the effects of the garmonization process. There are many issues, except the one I was concerned about, to be examined. I believe that further researches in the area will shift from the effect of IPR on overall economic growth to more specific areas, such as its effect on employment, rate of innovation and income inequality.

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Appendix

Figure 1. Seasonal patterns of 9 productivity indices

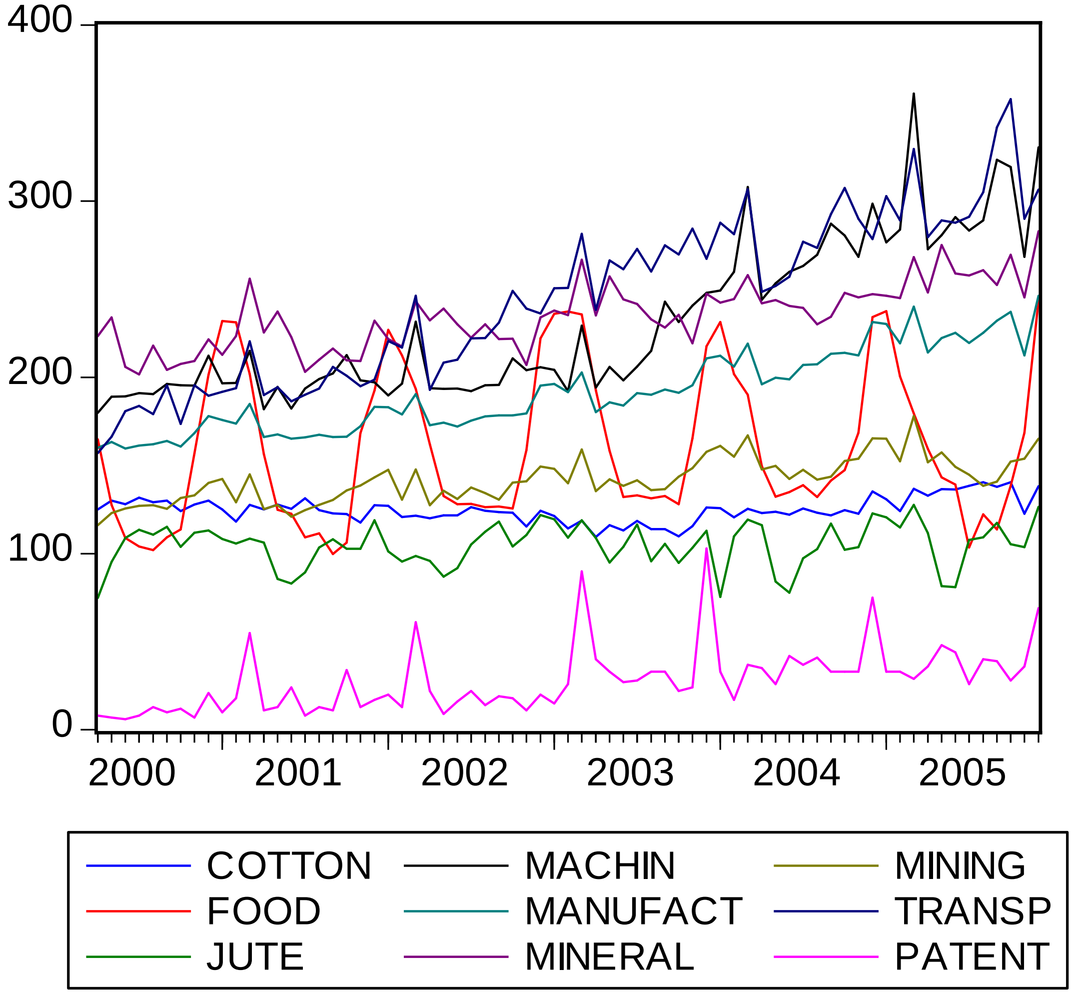


Figure 2. Seasonal pattern in *patent* variable

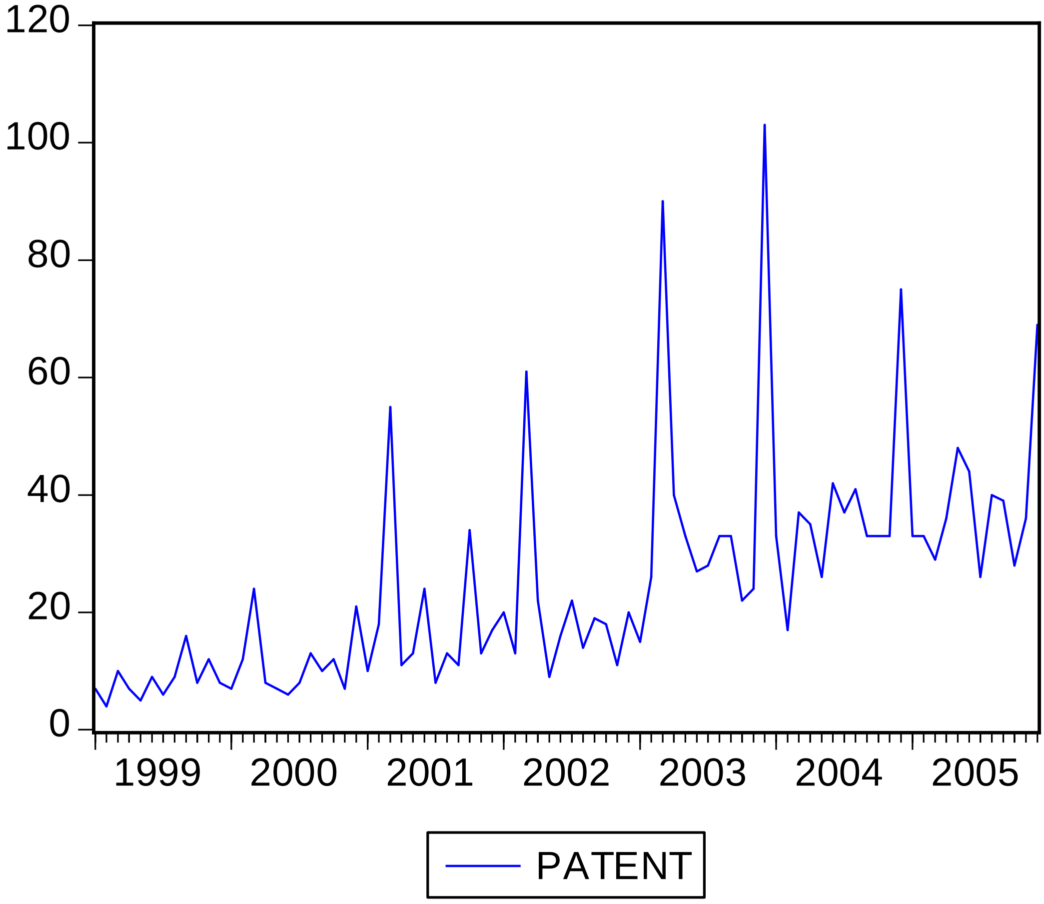


Figure 3. Variable *patent* seasonally adjusted

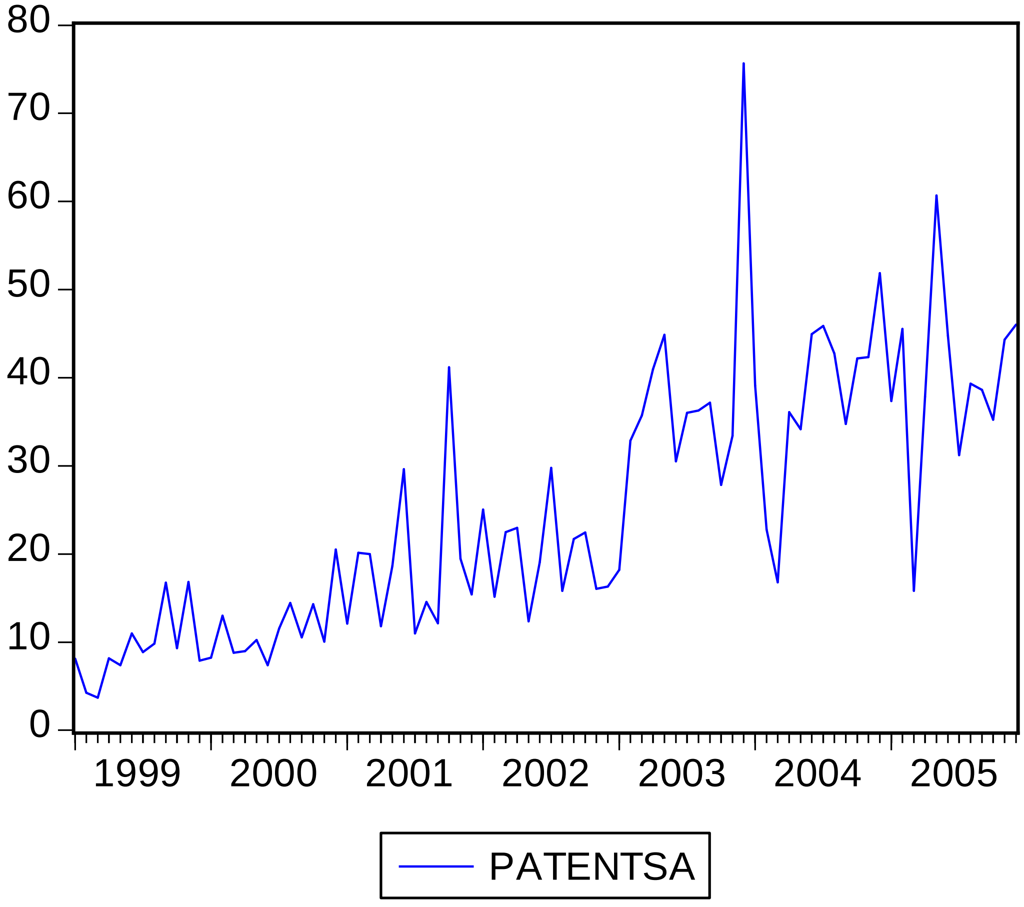


Figure 4. FDI and portfolio investment

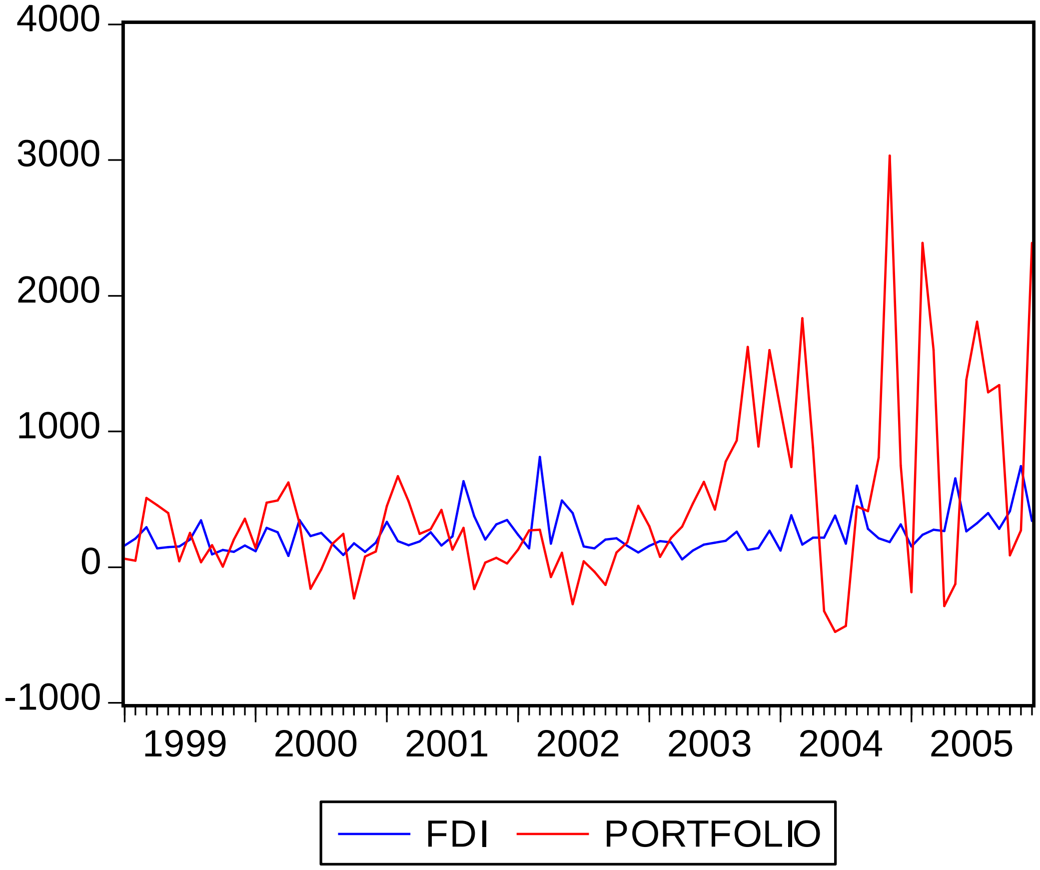


Figure 5. Structural breaks examination 1

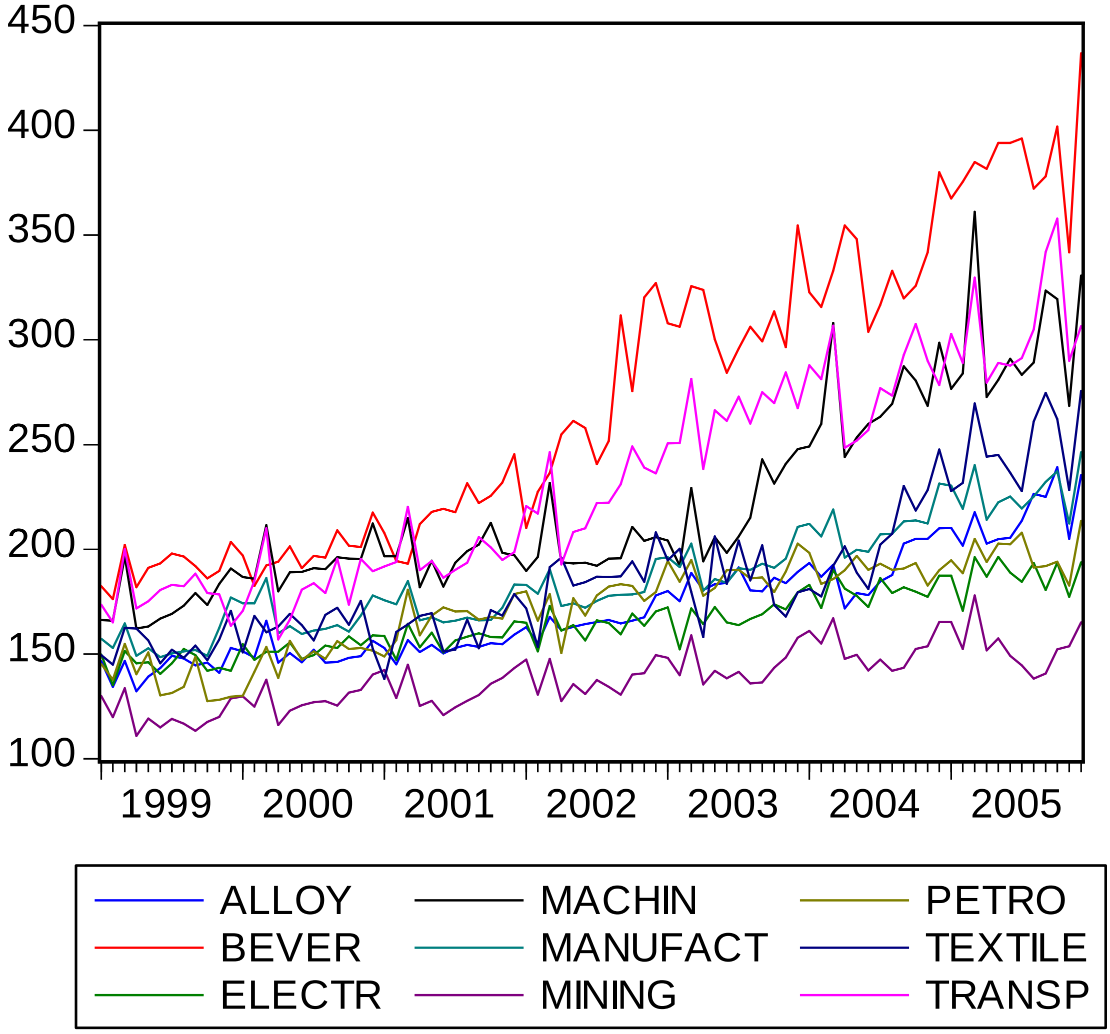


Figure 6. Structural break examination 2

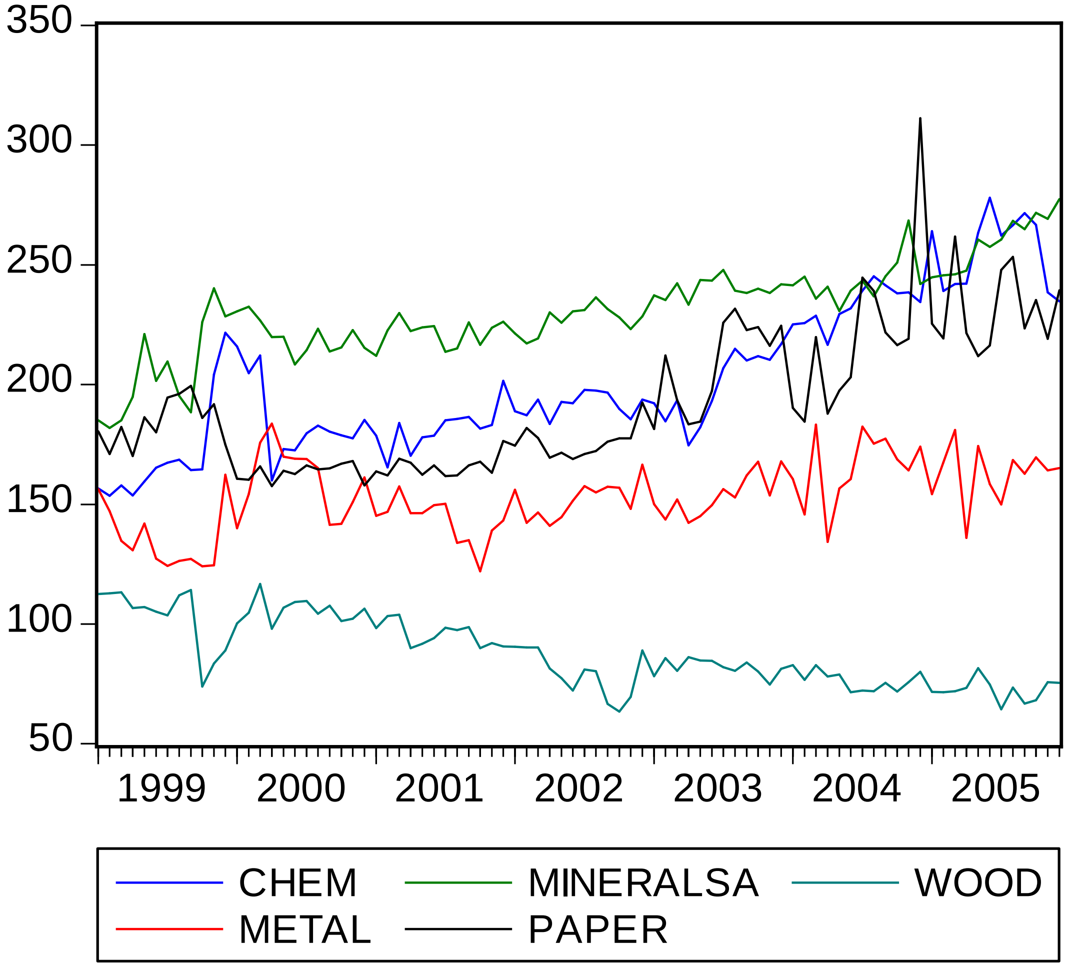


Figure 7. Structural break examination 3

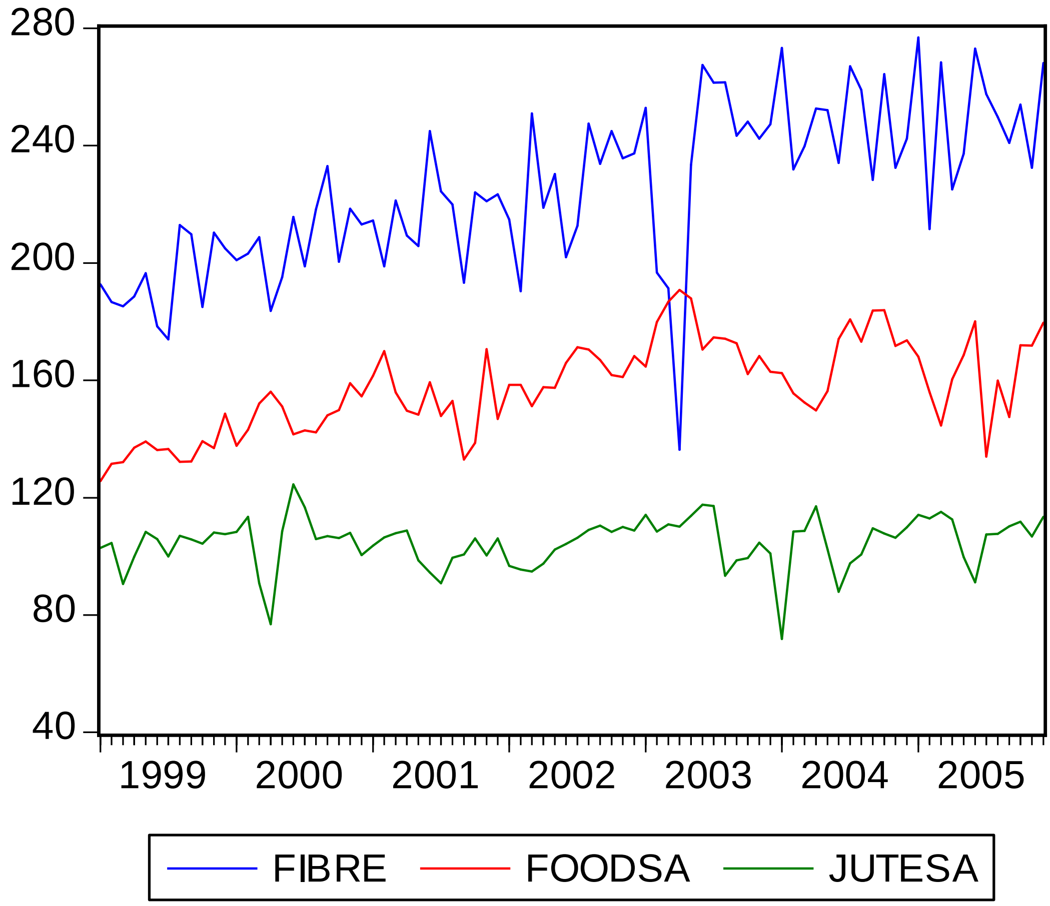


Figure 8. Impulse responses, main model

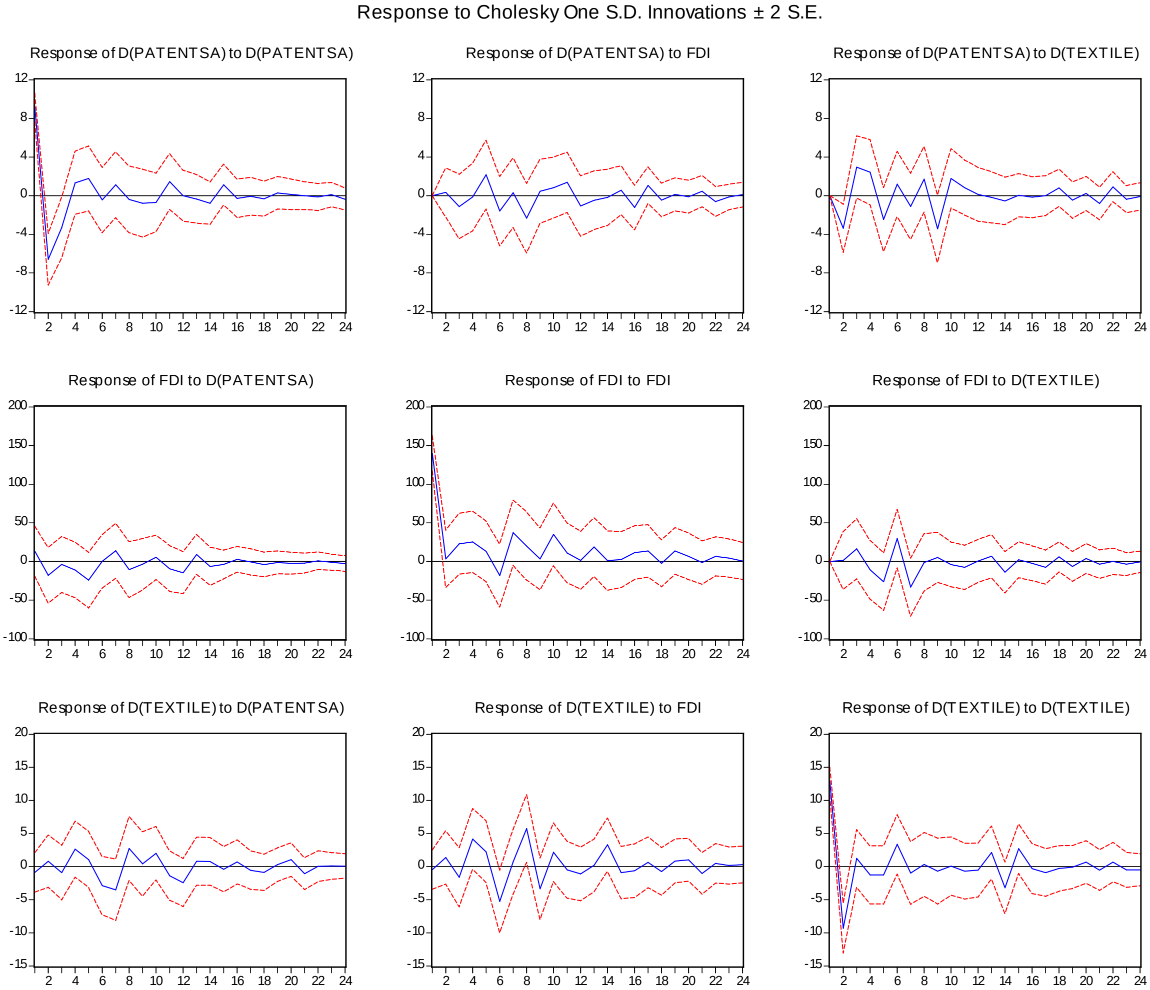


Figure 9. Impulse response, alternative model

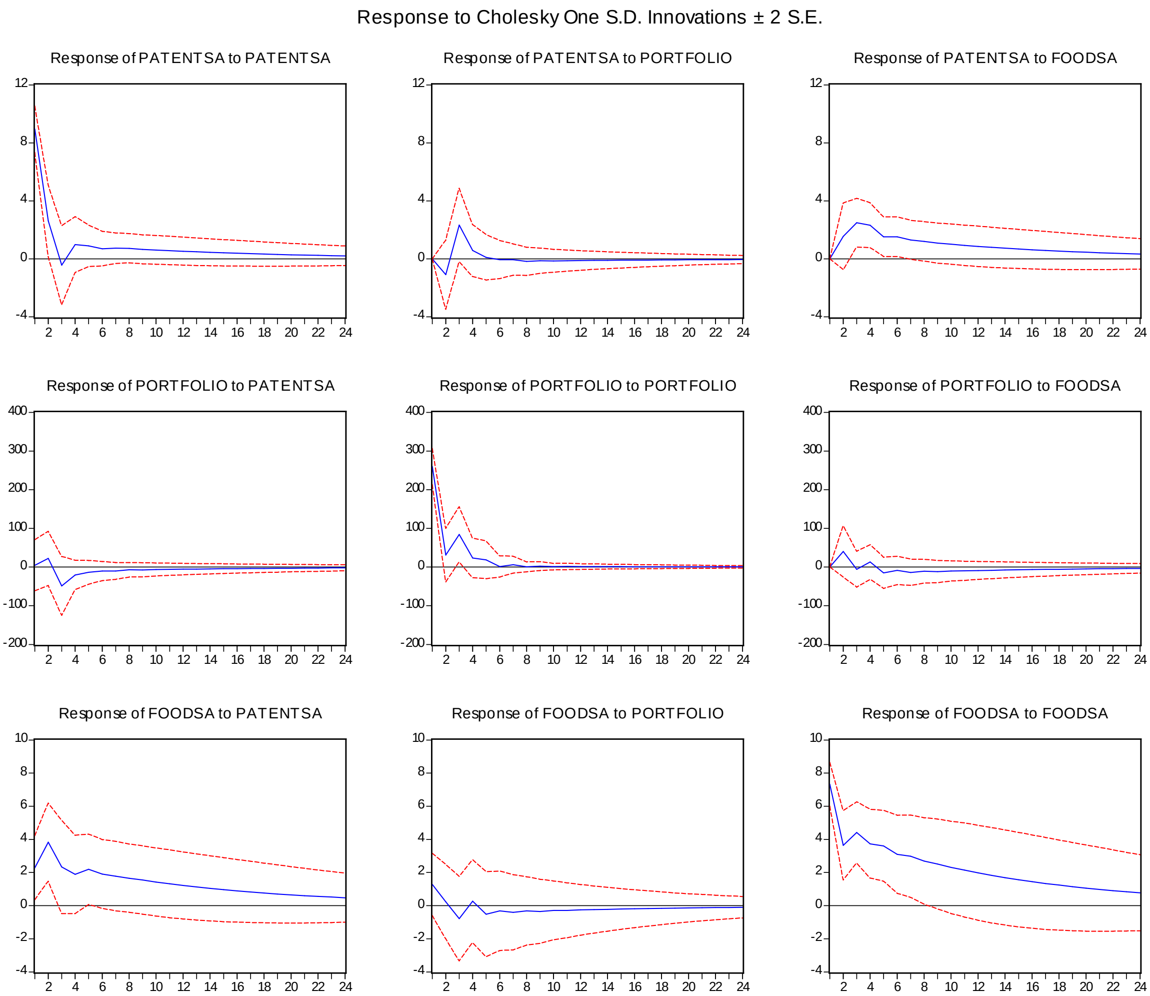
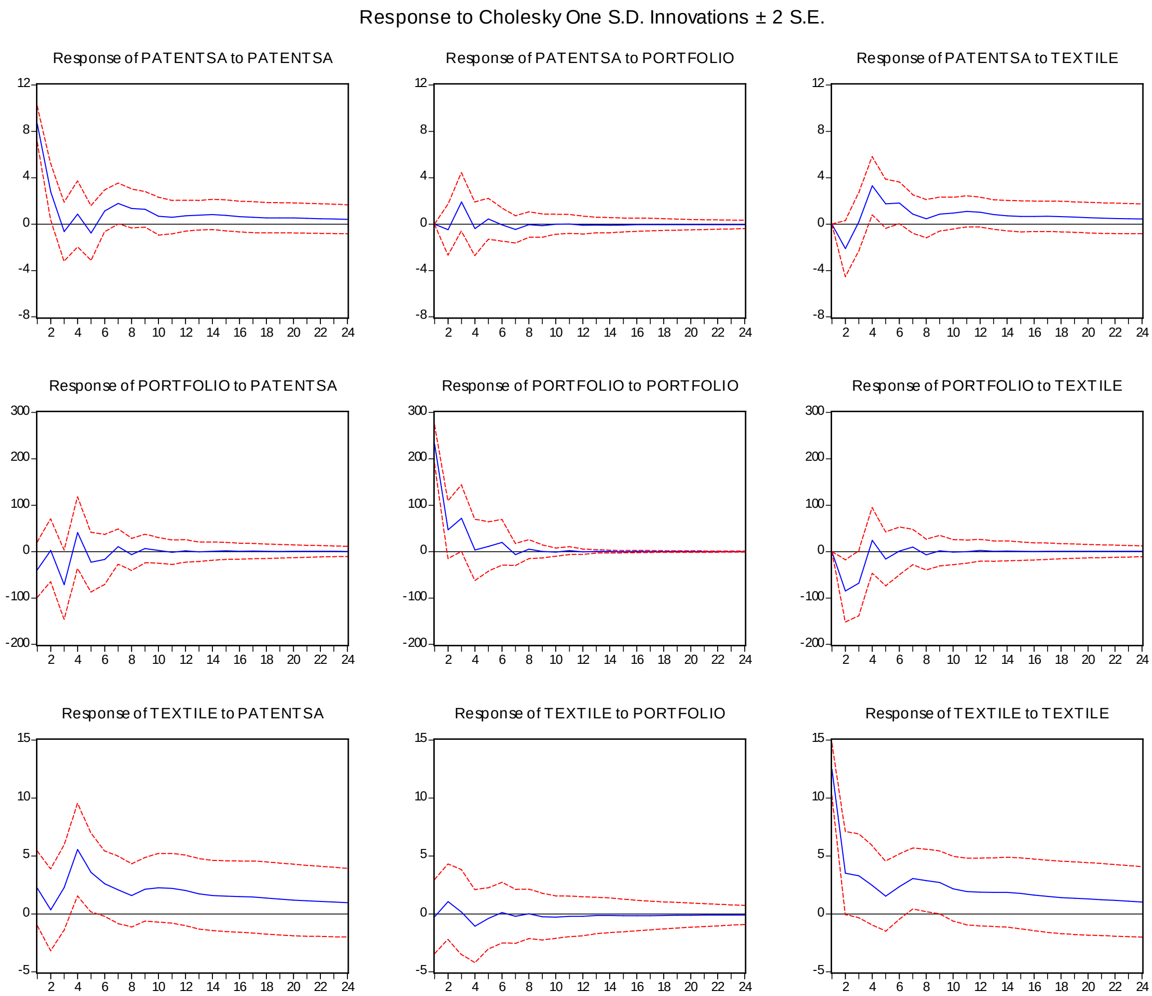


Figure 10.



Response to Cholesky One S.D. Innovations ± 2 S.E.
Response of PATENTSA to PATENTSA
Response of PATENTSA to PORTFOLIO
Response of PATENTSA to TEXTILE
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Table 1. Description of the indices of industry productivity

Variable	Description
alloy	Basic metals and alloys industries
bever	Beverage, tobacco and related products
chem	Basic chemicals and chemical products (except products of petroleum and coal)
electr	Electricity
fibre	Wool, silk and man-made fibre textiles
food	Food products
jute	Jute and other vegetable fibre textiles (except cotton)
machine	Machinery and equipment other than Transport equipment
manufact	Manufacturing industries
metal	Metal products and parts, except machinery and equipment
mineral	Non- metallic mineral products
mining	Mining and quarrying
paper	Paper and paper products and printing, Publishing and allied industries
petro	Rubber, plastic, petroleum and coal products
textile	Textile products (including wearing apparel)
transport	Transport equipment and parts
wood	Wood and wood products, furniture and fixtures

Table 3. VAR stability and serial correlation in residuals

Variable	Time period	Lag length	VAR stability	Serially correlated residuals
d(alloy)	1999m01-2005m12	1	*	no
		4	*	2
		7	*	no
d(bever)	1999m01-2005m12	1	*	1
		2	*	1,2
		3	*	no
d(chem)	2000m04-2005m12	1	*	1
		11	*	4
		12	*	no
d(electr)	1999m01-2005m12	1	*	1
		2	*	1,2
		3	*	1,2,3
		11	*	2,8
		12	*	no
d(fibre)	1999m01-2005m12	1	*	1
		10	*	no
		12	no	
foodsa	1999m01-2005m12	1	*	1
		3	*	2,3
		6	*	no
jutesa	1999m01-2005m12	1	*	1
		2	*	no
d(machinesa)	1999m01-2005m12	2	*	1,2
		3	*	2,3
		7	*	no
		10	no	
d(manufactsa)	1999m01-2005m12	1	*	1
		3	*	3
		10	no	
metal	2000m09-2005m12	3	*	1,3
		4	*	no
		12	no	
d(mineralsa)	2000m06-2005m12	6	*	1,4,5
		10	*	9
d(miningsa)	1999m01-2005m12	3	*	3
		4	*	4
d(paper)	2000m01-2005m12	2	*	1,2
		3	*	3
		9	*	7
		12	no	
d(petro)	1999m01-2005m12	1	*	1

		3	*	2,3
		7	*	no
		12	*	2,12
d(textile)	1999m01-2005m12	3	*	1,2
		4	*	no
		7	*	no
		12	no	
d(transportsa)	1999m01-2005m12	3	*	1,2,3
		7	*	2
		9	*	no
d(wood)	2000m01-2005m12	3	*	2

Table 6. VAR stability and serial correlation in residuals, alternative model

Variable	Time period	Lag length	VAR stability	Serially correlated residuals
alloy	1999m01-2004m04	1	*	1
		2	*	no
		11	no	
		12	no	
bever	1999m01-2004m04	1	*	1
		2	*	2
		11	no	
		12	no	
chem	2000m04-2004m04	2	*	1,2
		10	no	
		12	no	
electr	1999m01-2004m04	1	*	1
		2	*	1,2
		3	*	no
		9	no	
		12	no	
fibre	1999m01-2004m04	1	*	no
		2	*	no
		3	*	no
		12	no	
foodsa	1999m01-2004m04	1	*	1
		2	*	no
		12	no	
jutesa	1999m01-2004m04	1	*	1
		3	*	no
		12	no	
machinesa	1999m01-2004m04	1	*	1
		2	*	1
		3	*	no
		8	*	4,8
		12	no	
manufactsa	1999m01-2004m04	1	*	no
		2	*	no
		12	no	
metal	2000m09-2004m04	1	*	no
		3	*	no
		8	*	8
		11	no	
		12	no	
mineralsa	2000m06-2004m04	1	*	no
		9	no	
		12	no	
miningsa	1999m01-2004m04	1	*	1
		2	*	no
paper	2000m01-2004m04	1	*	no
		4	*	no
petro	1999m01-2004m04	1	*	1
		2	*	no

		12	no	
textile	1999m01-2004m04	1 3 12	* * no	1 no
transportsa	1999m01-2004m04	1 2 11 12	no no no no	
wood	2000m01-2004m04	1 12	* no	no