

Transition into knowledge-based economy: Relevance of Korean experience to growth perspectives in Uzbekistan¹

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Abstract

By utilizing unique approach, paper analyzes the applicability of successful Korean experience of transition into-knowledge economy to the development perspectives of Uzbekistan. Policy variables are calibrated by matching the respective stages of transition. Applicability is investigated by both qualitative and quantitative analysis within the framework of endogenous growth theories using quarterly data for Uzbekistan during the period of country's independence. Conclusions derived suggest that there is significant relevance of Korean experience for further knowledge-induced growth perspectives in Uzbekistan. Specifically, Uzbekistan would benefit from Korean experience in spheres of coordinating human capital development and foreign knowledge-inflows, macroeconomic stability, financial liberalization.

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Introduction

With decreasing returns to exogenous physical factors of production in neoclassical models of growth, in spite of controversial propositions on the input of knowledge as an endogenous source of growth, transition into innovative system of development has far been validated by wide range of empirical researches as vital source of long-term growth and income convergence for developing countries (Romer, 1990; Aghion and Howitt, 1998; Grossmann and Steger, 2007).

Hence, transition into knowledge-based economy has been strategic objective for developing countries striving to assure their long-term growth, competitiveness as well as convergence of their income levels towards those in advanced states. Even though general development policies have been concentrated on stimulating investments into production, adaptation and dissemination of knowledge and innovations speed and quality of transition has varied from country to country. That is simply because transition of the developing world into knowledge-based system is a rather complex process requiring comprehensive stimulation of R&D sector, enhancement of human capital base, creation of necessary infrastructural, institutional and legal framework as well as contemporary adoption and adaptation of scientific and technological advancements within massively globalization world community.

From the early stages of independence from the former Soviet Union Uzbekistan has undertaken gradual steps towards building knowledge-economy. Devastated socio-economic situation was inherited from the Soviet Union when Uzbekistan declared its independence in 1991. During 1985-1990 years country was the poorest region within the Union with annually declining productivity rates of labor and capital by more than 20% and 6%, respectively. Material-output ratio decreased by 2-3% during the pre-independence period with capital formation shaping barely around 20% of national income (Saidova, 1998). From the early stages one of the policy priorities, thus, became improving aggregate productivity by promoting modernization of national economy, improving labor efficiency by enhancing human capital base, stimulating the production and adaptation of knowledge and technologies, dissemination of innovations across sectors of production.

On the other hand, for the last half a century, Korea has emerged as a model economy that transformed from laggard to one of the leaders along the world technological frontier standing out as the most innovative economy in Bloomberg's Global Innovation Index as of 2014 followed by Sweden (2nd) and the US (3rd) (Lu and Chan, 2014). Absence of technological progress in South Korea's growth in line with other East Asian miracle economies (Kim and Lau, 1994) as well as subsequent Krugman's (1994) pessimism on gradual slowdown of growth in those countries has been rejected by not only series of empirical analyses (e.g. World Bank, 2001; Lau and Park, 2003; Madsen and Ang, 2009, 2013) but also the reality of the last several decades. Subject to noticeable fluctuations during 1961-2004, average contribution of technological progress, equally, Total Factor Productivity (TFP), into per-worker economic growth and aggregate real income growth of Korea has been roughly around 38% and 26%, respectively (Hahn and Shin, 2010)³. Korean per-capita income increased by eleven-fold during 1960-2003, while the analogous change would be roughly four-fold without TFP growth –

³Numbers representing the contribution of TFP into Korean economic development are robust in comparison to similar researches Collins and Bosworth (1997) and World Bank (2001).

representing the significant positive impact of the country's transition into knowledge economy on growth (World Bank, 2006).

Successful transition path of Korea towards knowledge economy was enabled by credible and sound socio-economic policies promoting human capital development, R&D, technology adaptation and diffusion, efficient institutional build-up in addition to absolute advantages related to demographic and geographic conditions at initial stages (Kim, 1991; Madsen and Ang, 2013). Henceforth, relevance of Korea's development story – the 'Miracle on Han river', for developing world is strongly associated with applicability of the successful and swift transition of Korea into knowledge based system (Kim, 1991; Harvie and Lee, 2003).

Using unique approach, this paper intends to examine the pertinence of Korean experience of transition into knowledge-based economy for long-term growth strategy of Uzbekistan – a country striving towards innovative economy since early stages of its independence in 1991.

Research utilizes comprehensive and unique approach to test the applicability of the Korean experience of transition into knowledge-based economy to the case of Uzbekistan. In doing so, research addresses following two crucial issues:

Firstly, research proposes that transition into knowledge-economy of developing countries is a multistage process with different but gradual and interlinked policies yielding expected positive outcomes at different stages of development. Thus, generalizing the conclusion of Almeida and Teixeira (2008) on asymmetric impact of innovation policies at different stages of development, Korean experience of successful transition into innovative system should be matched, predominantly, to the respective socio-economic and institutional conditions at the current development stage of Uzbekistan. This proposition intuitively refers to comparative analysis as necessary condition.

Secondly, it is further argued that impact of similar policies implemented by the model Korean economy at matched stages of development may be applicable (both statistically and economically positive impact) or inapplicable (insignificant or negative impact) to the case of Uzbekistan because of changes in time and exogenous external factors as well as economy and country specific differences. This argument, in turn, implies that comparative analysis of applicability of Korean model experience of transition into innovative economy is necessary but not sufficient condition. There emerges a need for additional empirical investigation of the applicability of Korean experience to the case of Uzbekistan using available theories of knowledge-induced development.

Finally, this innovative approach provides robust and substantiated conclusions on the degree and depth of relevance of analogous Korean experience for Uzbekistan – conditional upon the complementariness of the comparative analysis and empirical investigation. Qualitative and quantitative results serve to draw conclusions on the key question: what concrete options from Korean experience are effective for Uzbekistan striving towards knowledge-economy with prevailing similarities and differences?

Further, research is structured as follows: the first section critically reviews relevant literature on endogenous growth theories and key aspects of Korean transition into knowledge-based system; the second section lays out the methodological framework for empirical investigation of

applicability of Korean experience for Uzbekistan within endogenous theories; and the third section provides conclusions and recommendations for Uzbekistan reflected from the relevant aspects of Korean economic transition into knowledge-based system.

Theoretical framework on endogenous knowledge-induced growth

Post-neoclassical development theories which endogenize the knowledge-based growth tendencies across countries have created general framework for empirically investigating the policies for transition into knowledge-based economy.

In 1980's application of neoclassical models to empirical growth rates across countries and groups have left significant portion of growth on the burden of the factor of technological development (Romer, 1990). Post-neoclassical fully endogenous growth theories consider the knowledge as an endogenous factor with increasing returns to production which results from partial excludability, spillover effects and externalities of knowledge and innovations (Romer, 1986, Grossman and Helpman, 1991). Accordingly, one-time permanent government policies stimulating innovation generation, adoption, adaptation and diffusion should permanently increase the long run rate of growth. Transition of less developed countries into innovative system takes place mainly by imitation of new or improved goods and services from highly-innovative countries.

However, propositions of fully endogenous models were not valid when tested empirically on growth experiences of individual countries and high-income country-groups ('Jone's critique', Jones 1995a, 1995b). 'Jone's critique' brought up the second generation *semi-endogenous* and *Schumpeterian models* of endogenous growth which maintained fairly significant applicability for analyzing knowledge-based development tendencies across countries.

According to semi-endogenous theories factors stimulating R&D sector should constantly be increased in order to maintain continuous productivity growth rates (Jones, 1995a, b). Factors of knowledge production, adoption and dissemination are imposed assumption of decreasing returns to scale avoiding the 'scale effects' of first generation fully-endogenous theories.

Jones (1995b) presents general knowledge-stimulated productivity growth within semi-endogenous theories as:

$$\hat{A} = \partial L_A \quad (1)$$

Where A – is a knowledge factor in economy, L – is labour. Production of new knowledge within an economy is primitively dependant on two factors: a) number of labour devoted to R&D sector, L_A b) rate of success of innovations in R&D projects, ∂ . Semi-endogenous theories propose that rate of successful innovations, contemporarily, is a function of knowledge stock, A, available in economy:

$$\partial = \varphi A_{t-1}^{\phi} \quad (2)$$

Where ϕ measures the degree of externality from knowledge and innovations. In turn, this proposal carries two alternative hypotheses. On the one hand, assuming positive externalities from the available stock of knowledge, rate of successful innovation should increase as knowledge stock increases ($\phi > 0$). On the other hand, as stock of innovations increases innovating something new becomes harder and harder, thus, possibility of being successful becomes smaller and smaller ($\phi < 0$). Both of these hypotheses imply that effects of the

knowledge stock enters the model as an external factor for the labor in R&D sector, L_A , and when $\phi = 0$ there is no externality from knowledge, thus, creation of new knowledge is independent of the available knowledge stock (Jones, 1995b).

Innovation function (1) characterizes another distinctive feature related to distortion in the knowledge production resulting from duplication or re-invention of existing innovations. Duplication effects can roughly be reflected by L_A^ϕ , where $0 < \phi \leq 1$ as if any duplication is equal to as if there is less labor working in R&D sector (Jones, 1995b). Extracting the externality effect of duplication from labor factor:

$$L_A^\phi = L_A L_A^{1-\phi} = L_A l_A^{1-\phi} \quad (3)$$

Where l_A characterizes duplication externality and equals to L_A in the long run balanced growth path. Combining (1) and (2) into (3) results in semi-endogenous knowledge-based productivity growth function:

$$\hat{A} = \phi L_A A_{t-1}^\phi l_A^{1-\phi} \quad (4)$$

Although Romer (1990) argues that returns to knowledge whether it is increasing or decreasing is a philosophical concern Jones (1995b) assigns decreasing returns to knowledge ($\phi < 1$) for consistency with observed time-series data. According to (4) knowledge-based development is mainly determined by available knowledge stock and innovative markets. Continuous knowledge and technology inflows into economies should be stimulated, based on semi-endogenous theories, in order maintain continuous growth rates in economies.

Schumpeterian endogenous growth theories predict economic growth to take place on the bases of product proliferation in countries resulting from factors stimulating the production, adoption and dissemination of knowledge (Aghion and Howitt, 1998; Peretto, 1998). That is, increasing R&D inputs spread over horizontally and/or vertically expanding product and service varieties and spurs economic growth as if there are constant returns to scale on knowledge accumulation in economies (Ha and Howitt, 2007). Long-term knowledge based development within Schumpeterian theories takes the form of:

$$g_A = g_Y = \lambda \left(\frac{L_A}{Q} \right)^\sigma \quad (5)$$

where the σ is the duplication parameter and Q represents the product varieties in economy expanding from factors stimulating production and dissemination of knowledge and innovations. Accordingly, growth in countries is sustained only if the R&D input, L_A , is increased in order to cope with increasing range and complexity of differentiated products in the economy (Ha and Howitt, 2007). International knowledge-spillovers serve to stimulate growth based on increasing number of products within economies both by quality and quantity.

Propositions of semi-endogenous and Schumpeterian theories of knowledge-based growth have been validated for developed countries by Jones (1995b), Madsen (2007), Ha and Howitt (2007), Zachariadis (2004) and developing countries Ulku (2007), Saxena *et al* (2008), Madsen and Ang (2009, 2013), Islam (2008). Little support for knowledge-based growth theories is found by Bosworth *et al* (1995) and Kim and Lau (1994) where physical capital accumulation, rather than TFP growth, has been the major source growth in East-Asian developing countries.

Review of Korea's transition into knowledge-economy

Lee and Yu (2002), based on growth accounting estimation, show that Krugman's (1994) view on potentially slowing growth of Korea mainly induced by physical factors of production (Kim and Lau, 1994) was inappropriate. Instead, technological advancements combined with human capital development have been the key sources of immense growth and miracle transformation of Korean economy. Conclusions comply with findings of Singh and Trieu (1999) that growth of total factor productivity in Korea over 1965-1990 has been exceptional and it constituted, on average, 27% of average output growth.

Empirical investigations show that much of the knowledge-induced growth in Korea is explained by Schumpeterian theories (based on product differentiation) rather than semi-endogenous models (based on continuous R&D stimulus) (Madsen *et al*, 2010). Both domestic and inflow of foreign research intensities have played significant role for Korean endogenous growth. However, factors resulting in knowledge-based growth and effecting Korea's transition into knowledge-economy have varied across different phases. In spite of empirically substantiated applicability of endogenous growth theories on Korea's growth patterns, critical review of theoretical and empirical literature reveals that transformation Korea into highly-innovative system has evolved as a rather multiphase phenomenon, consisting of '*start-up*' (1960-1980), '*adoption and adaptation*' (1980-1990's) and '*innovative*' (*current stage of Korea's development*) stages.

Initial stage is characterized with Korea's low productivity growth rates (on average, 0.8%) as at this stage institutional and legal framework is to be built and there is low coordination between factors affective endogenous growth (Hahn and Shin, 2010). Another distinctive feature of this stage is the low capital-labor ratio. Therefore, it was natural for Korea at initial '*start-up*' stage of transition to incur low TFP growth rates without significant knowledge-capital accumulation (Kim, 2002).

Endogenous growth theories propose that rate of innovativeness is dependent on the available knowledge-stock, which is significantly greater in developed countries than developing ones. In fact, World Intellectual Property Organization (2010) reports that 83-90% of patent applications filed worldwide during 1990-2008 years originated from OECD countries. Consequently, stimulating R&D sector yields significant positive impact on innovativeness only in highly-innovative economies, while similar policies does not result in noticeable productivity-induced growth in developing world (IMF, 2004). Thus, 'transition' of less-innovative countries into knowledge-based system is rather referred to 'adoption and adaptation' of competitive knowledge and advancing technologies than their 'creation' (Coe and Helpman, 1995).

As correct and effective policies result in swift acquisition of available knowledge, high TFP growth rates in Korean economy during 1980's (average 3.4%) and 1990's (average 1.7%) can be attributed to the 'adoption and adaptation' stage (Hong, 2011).

By at the end of the 'adoption and adaptation' stage, policies stimulating domestic R&D and innovativeness yield increasing productivity-induced growth in countries (Aghion and Howitt, 2009). At 'innovative' stage, where Korea has reached world technological frontier, TFP growth rates slowed down to roughly 1.4% annually (Madsen and Ang, 2009) because impact of foreign technology inflows gradually faded away and rate of innovation-introduction into the economy

slowed down as innovating something new becomes harder and harder as predicted by Jones (1995b).

Overall, Korean transition is unique as of its swift and successful completion of the ‘start-up’ and ‘adoption and adaptation’ stages with correct and effective policies implemented at each stage. Empirical investigations reveal that Korean transition, evolved as model for today’s developing countries, is characterized with number of outstanding aspects.

Human capital

Firstly, Korean policies have consistently promoted human capital development throughout all stages of its transition into knowledge-economy which, in turn, induced technological progress and efficiency of physical capital (Lee and Yu, 2002), served to continuously attract physical (Pyo, 1995) and played significant role for adopting and adaptation of foreign technologies, thus, moving the economy towards world technological frontier (Madsen *et al*, 2010, Madsen and Ang, 2009).

Education system was supported by more than one-fifth of government expenditure from the early 1980’s – the beginning of ‘adoption and adaptation’ stage. Massive public spending on human capital development increased the literacy rate from 22% in 1953 to almost 100% by the mid of the analogous stage of transition into knowledge economy. Upon the literacy accomplishment, policies were directed to establish close tie between education and science and technology in order to create human capital base that would be able to not only detect and master the foreign technology flows but also create new ones – competitive at global levels (Kim, 1991). Research universities have served as an institutional base along the ‘adoption and adaptation’ stage.

Foreign knowledge transfers

Secondly, impact of foreign knowledge and technology inflows on Korean endogenous growth has been significant. Specifically, exports, imports and FDI inflows accounted for most of the knowledge accumulation in Korea during the ‘adoption and adaptation stage’.

Policies liberalizing the Korean market at had both statistically and economically significant positive effect on accumulation of knowledge in the country (Lee and Yu, 2002). Importing innovative technologies or knowledge-embodied intermediate inputs increased the quality and/or differentiation of products and services as well as the efficiency of production processes as proposed by Grossman and Helpman (1991). Thanks to the strong human capital base and institutional build-up at the beginning of the ‘adoption and adaptation’ stage, scale of impact of international knowledge spillovers through trade on endogenous growth was significant upon the availability of high skilled labor force that was able to detect, master and improve the trade embodied tacit knowledge (Madsen and Ang, 2009).

Moreover, during technology ‘adoption and adaptation’ stage of Korean transition exporting Korean manufacturers did not significantly benefit by interacting with international buyers and competitors an Aw *et al* (2000). Thus, exports were not an important channel of knowledge inflows. On the contrary, within outward-looking export promotion policies, which provided several incentives to exporters (no tariffs on imports of intermediate capital and raw inputs, wide

access to bank and foreign loans), producers were encouraged to adopt competitive technologies and innovations. This, in turn, was one of the driving forces of Korean transition into knowledge-based system (Kim, 1991).

Liberalization of direct investments into Korean economy started from the beginning of Korea's 'adoption and adaptation' – the early 1980's. Even though role of FDI as a vital channel of technology transfers is found to be significant and positive only at sectoral levels (Choi and Hyun, 1991; Hong, 1997), whereas aggregate impact on productivity is found to be insignificant, comparative analysis shows that FDI flows brought the key knowledge and technological bases for Korea's long term competitiveness (Kim and Hwang, 2000). Despite of noticeably small amount of FDI flows relative to the size of the economy and overall domestic investments, direct investments contributed purely to the enhancement of productivity of manufacturing sector. That is to say, technology transfers were not biased at the absence of resource-seeking FDI flows into Korean economy (Asiedu 2004, 2005). Moreover, Korean policies imposed several requirements on foreign investments *e.g.* local content, exporting, technology transfers which was directed to fundamentally stimulate international knowledge spillovers into the economy (Kim and Hwang, 2000).

Stable macroeconomic environment and business financing

From beginning of 'adoption and adaptation' stage, Korean policies were directed to stabilize economy and support business activities. Inflation rate substantially declined from 28.7% in 1980 to 7.2% in 1982 and has been kept within 2-3% interval over the last decade. Stable macroeconomic conditions helped manufacturers make solid long-term investment decisions in terms of achieving long term productivity and efficiency. Along with assuring stable economic environment, government successfully shifted R&D investment from public to private sector using series of incentive instruments. Share of R&D spending by private sector increased substantially by 63 times from early 1970's to late 1980's (Kim, 1991).

Application of endogenous growth theories shows that access to financing has been one of the key factors of knowledge-induced growth in transformation of Asian miracle economies including Korea (Madsen and Ang, 2009). Availability of financing enabled Korean firms engage into productivity enhancement processes (R&D spending, developing and acquiring technology, human capital development). As a result of liberalization of Korean financial system during the 'adoption and adaptation' stage, domestic credits to private sector (as share of GDP) increased from 5.8% in 1960 to 48% in 1985 and, further, to 145% in 2012 (World Bank, 2014).

Methodology framework for empirically testing the validity of Korean experience for Uzbekistan

The stages of transition of Uzbekistan and Korea are matched by the tendencies of productivity growth rates of the economies according to the propositions of the endogenous growth theories and review of empirical literature. Further, degree of applicability of policies implemented by Korean government at matching stage of Uzbekistan's transition is tested along with the validity of semi-endogenous and Schumpeterian models of growth.

Methodological frameworks by Ha and Howitt (2007) and Madsen *et al* (2010) are adopted as basis for the analysis. By combining the R&D input factor and replication parameter in (4), knowledge production model based on semi-endogenous theories is expressed as:

$$\hat{A} = \varphi X^\sigma A^\phi \quad (6)$$

Where X – R&D input and decreasing returns to knowledge assumption is maintained by $\phi < 1$. Further reformulating (6):

$$\ln\left(\frac{\hat{A}}{A}\right) = \ln \varphi + \sigma \ln X + (\phi - 1) \ln A \quad (7)$$

$$\ln\left(\frac{\hat{A}}{A}\right) = \ln \varphi + \sigma \left[\ln X + \frac{(\phi - 1)}{\sigma} \ln A \right] \quad (8)$$

Productivity growth from knowledge production and dissemination is predicted to be constant at the steady path of growth corresponding – if growth experience in Uzbekistan is within certain stage of its transition into knowledge-based system. Therefore, the left side of (8) is expected to form stationary trend. The equation in the square brackets, $\left[\ln X + \frac{(\phi - 1)}{\sigma} \ln A \right]$, in the right side must also demonstrate stationary interrelation. This means $\ln(X)$ and $\ln(A)$ must be co-integrated with the second element of the co-integration vector being strictly negative because of the diminishing returns to knowledge assumption imposed (Ha and Howitt 2007). Considering the statistical properties of the R&D inputs and productivity measures, both research activity factors and TFP levels must be integrated of the same order as R&D inputs has only temporary effects on growth rates of productivity whereas permanent effects are irrelevant as predicted by the semi-endogenous theories (Jones, 1995). Expectations should be met if growth tendencies in Uzbekistan are explained by the semi-endogenous growth theories in contrast to the case of Korean experience.

In case of Schumpeterian theories knowledge-based growth patterns in Uzbekistan follows as:

$$g_A = \lambda \left(\frac{X}{Q} \right)^\sigma \quad (9)$$

Where, Q represents the product varieties in the economy. Assumption of constant returns to knowledge is maintained within cope with Schumpeterian theories (Madsen *et al*, 2010). Reformulating (9):

$$\ln(g_A) = \ln \lambda + \sigma [\ln X - \ln Q] \quad (10)$$

If Uzbekistan's transition path towards knowledge-based system has been in accordance with Schumpeterian models as in the case of Korea, there must be co-integrating relationship in $[\ln X - \ln Q]$ *i.e.* R&D inputs should be followed by increasing variety of products and services with co-integration factor moving around negative unity (Madsen, 2007). Furthermore, factors of research intensity in Uzbekistan, X/Q , and productivity growth rates, g_A , must be integrated of the same order.

Tests for stationarity and cointegration are undertaken by ADF and Johansen's methodologies, respectively.

Summarized tests should provide necessary but not sufficient conditions for validating the Korea's transition experience for Uzbekistan. Therefore, analysis further utilizes principal time-

series estimations to empirically investigate the applicability of factors standing out from the Korean experience to the growth patterns in Uzbekistan. To do so, following model, presented initially by Ha and Howitt (2007), is adopted:

$$g_A = \lambda \left(\frac{X}{Q} \right)^\sigma A^{\phi-1} W^\mu$$

$$Q \propto L^\beta \text{ at the steady state} \quad (11)$$

Where, g_A – aggregate productivity growth rates in Uzbekistan, X is factor representing R&D input in Uzbekistan; Q is existing product varieties in Uzbekistan; X/Q represents the overall research intensity in Uzbekistan; λ is the R&D productivity parameter; σ is innovation duplication parameter (zero is the innovation is the replication of existing ones and one if the innovation is entirely new), ϕ is the returns to knowledge and β is the product proliferation coefficient. Finally, W is the vector of factors that played significant role during the successful transition of Korea into knowledge-system.

By reformulating (11) and calibrating Korean-experience-specific factors into the equation, estimation model takes the form of:

$$\Delta \ln A_t = \beta_0 + \beta_1 \Delta \ln X_t + \beta_2 \ln \left(\frac{X}{Q} \right)_t + \beta_3 \ln S_t + \beta_4 (\Delta \ln X_t^f) + \beta_5 \ln \left(\frac{X}{Q} \right)_t^f + \beta_6 \ln \left(\frac{A_t^{World}}{A_t^{UZB}} \right) + \beta_7 \ln(HC_t) +$$

$$+ \beta_8 \ln \left(HC_t * \frac{A_t^{World}}{A_t^{UZB}} \right) + \beta_9 \ln FL_t + \beta_{10} \ln(Stab)_t + \beta_{10} \Delta \ln(E_t) + \beta_{11} \Delta \ln(FDI_t) \quad (12)$$

Where:

- $\Delta \ln A_t$ - TFP growth rates in Uzbek economy;
- $\Delta \ln X_t$ and $\ln \left(\frac{X}{Q} \right)_t$ factors representing domestic R&D spending and research intensity in Uzbekistan;
- $\Delta \ln X_t^f$ and $\ln \left(\frac{X}{Q} \right)_t^f$ factors representing inflows of foreign knowledge and technologies through imports;
- (A^{World}/A^{UZB}) – technology frontier factor capturing the extent of the technological convergence of Uzbekistan towards world technological frontier, or alternatively, the speed of country's transition;
- HC_t – human capital development in Uzbekistan;
- $HC_t * (A^{World}/A^{UZB})_t$ – determines the country's absorptive capacity of foreign knowledge and technologies;
- $S_{i,t}$ – available knowledge stock in Uzbekistan.
- $Stab$ – factor representing macroeconomic stability in Uzbekistan;
- FL_t – financial liberalization explains the dependency of innovativeness, technology-absorptiveness and productivity of industries and firms on financial environment in terms of R&D-investment opportunities, financial freedom and mobility and allocation of financial resources (Madsen *et al*, 2009).

- *FDI* and *E* foreign direct investments and exports, respectively, as alternative channels of knowledge inflows into the economy.

Data and Measurement

Estimations employ quarterly data from 1991 to 2011. Statistics are obtained from the public databases of State Statistics Office, Bureau of Patents of Uzbekistan as well as World Bank and World Intellectual Property Organization.

Productivity – A_t

TFP is calculated following classical Cobb-Douglas production function as in most of the empirical works: $A_t = Y_t / (L_t^\alpha K_t^{1-\alpha})$. Labor and capital are assumed to have constant returns to scale and α is share of labor's income in GDP of Uzbekistan. Labor compensation is proxied by ratio of wages paid to labor force to quarterly GDP volumes.

Stock of capital, K , in the country is calculated using the perpetuity method as:

$$K_t = I_t + (1 - \delta)K_{t-1}$$

Where, K_t is the accumulation of capital in period t , I_t is the aggregate investment during period t , and δ is the depreciation of capital. Madsen and Ang (2009) differentiate capital into machinery and non-residential capital and sets depreciation rates at 15% and 5%, considering the fact that machinery wears out faster. Similarly, for the analysis, depreciation rate is set at 15% for capital as most of the capital Uzbekistan was out of date during the pre-independence period.

Initial stock of capital is calculated by Solow model steady state approximation as:

$$K_{initial} = \frac{I_{initial}}{g_{avr} + \delta}$$

Where, $I_{initial}$ is the investment made into the country in initial period and g_{avr} is the average growth rates of aggregate investments over the analysis period of 1991-2011. Quarterly values on GDP and investments are deseasonalized.

R&D input - X_t

Domestic R&D input is measured government spending on research and development.

Product variety - Q_t

Product variety in Uzbekistan is approximated by number of trademarks (TM) in the country. Even though in the long run, product varieties are expected to be equal to labor in the economy according to Schumpeterian theories of knowledge-based growth (Ha and Howitt, 2007) as economy is not at the steady state, research excludes the labor force as a true value of product variety. Domestic research intensity $(X/Q)_t$ is, thus, proxied by the ratio of domestic R&D input to domestic product varieties.

Financial liberalization

Financial liberalization index is measured by the share of domestic credits provided to private sector to GDP accounting for an important factor of Korean transition into knowledge economy.

Stock of Knowledge - S_t

The available stock of knowledge, S_t , in economy is calculated using patents data by the perpetuity method. Initial stock of knowledge is produced from $S_t = PA_i / (g_i^{av} + \delta_i)$ – where PA_i is number of patent applications (by both domestic and foreign) in the initial period, g_i^{av} – average percentage growth in number of patents over the period and δ_i – depreciation rate (set at 5%) for knowledge capital (Madsen *et al*, 2010). Further, total stock of knowledge is calculated by $S_t = (1 - \delta_i)S_{t-1} + PA_t$.

Technological frontier - $(A^{World}/A^{UZB})_t$

Technological frontier is taken as the ratio of TFP of the USA to that of Uzbekistan, considering the US economy is leading the world knowledge frontier.

Foreign knowledge inflows - X^f and $(X/Q)^f$

Technology inflows into Uzbekistan are approximated by three variables: import-embodied knowledge-inflows, FDI and knowledge acquisition through exporting:

Import-embodied knowledge inflows

Following, Coe and Helpman (1995) and Madsen *et al* (2008, 2009) factors capturing the impacts of technological spillovers into regions of Uzbekistan within the scope of semi-endogenous and Schumpeterian theories are calculated as:

$$mp_t X^f = \sum_n [s_{i,t} * m_{hi_tech}] * \bar{X}_t^f$$

$$mp_t \left(\frac{X}{Q} \right)^f = \sum_n [s_{i,t} * m_{hi_tech}] * \left(\frac{X}{Q} \right)_t^f$$

Where, $s_{i,t}$ represents the share of import-partner i in total imports of Uzbekistan in the end of time t ; m_{hi_tech} represents the volume of high-tech imports in total imports. Two groups of imported products: *chemicals and chemical products* and *machinery and appliances* are considered to be high-tech imports as classified by State Statistics Office of Uzbekistan; n is the number of top trading partners of Uzbekistan over 1991-2011 years. 24 countries from where Uzbekistan imported mostly were considered. They are Austria, Belgium, France, Iran, Israel, Italy, Japan, Kazakhstan, South Korea, Kyrgyz Republic, Latvia, Malaysia, Russian Federation, Tajikistan, Turkey, Turkmenistan, Ukraine, United Kingdom, United States, China, Finland, Germany, Netherlands and Switzerland. Their accumulated shares in total imports of Uzbekistan range from lowest 80.68% in 1996 to highest 91.98% in 2006, assuring high credibility of the sample.

\bar{X}_t^i represents the average index of R&D inputs (number of scientists and engineers, R&D expenditures, and patent applications) of import-partners equal to 1 in the year 2000. Foreign research intensity product varieties, $(X/Q)^f$, are approximated by the ratio of R&D spending and labor in partner countries as in Madsen *et al* (2010).

Import-embodied knowledge inflows are adjusted for import penetration – mp_t (changes in the shares of total imports in relation to GDP of Uzbekistan). Adjustment to import penetration is

made in order to correct for technology inflows being proportional to propensity to import (Madsen *et al*, 2010).

Knowledge-acquisition from exporting and FDI

Quarterly FDI flows and export volumes are considered as alternative channels of knowledge-transmission into the economy of Uzbekistan.

Macroeconomic stability - $Stab_t$

Macroeconomic stability is roughly approximated by the changes in the overall price levels in Uzbekistan – the GDP deflator.

Human capital development - HC_t

Development of human capital is measured by average years of schooling of labor force in Uzbekistan by adopting the methodology of Barro and Lee (2010) with some adjustments. Level of average years of schooling is calculated as weighted sum of labor with high-school education, college education and tertiary education. Weights are taken as the share of each group in total labor force.

Summary of basic properties of data are provided in Table 1 in appendices.

Research outcomes and conclusions

General overview of Uzbekistan's transition path

Productivity growth in Uzbekistan was, on average, 1.1% throughout the period of 1991-2011. Even though there is increasing trend observed, fluctuations have been significant (Figure 1, appendices). Negative and high volatility during 1992-1998 can be attributed to poor macroeconomic conditions inherited from the Soviet Union (Figure 3, appendices). Despite of noticeable slowdown of the long-term increasing trend of productivity in the economy, country has made solid steps towards knowledge-based system overall.

Knowledge-induced growth constituted on average 35-38% of economic growth for the period of 2000-2011. Contribution of capital accumulation has been slowly increasing. This could be mainly due to low capital/labor ratio in the economy so as contribution of TFP growth is biased in capital-accumulation direction.

Calculated average years of schooling of labor force in Uzbekistan remained unchanged for two periods covering 1992-1998 and 1999-2006. However, as a result of the long-term human capital development program, initiated in 1997, under strong supervision of government analogous indicator increased from average 11.63 until 2006 to 11.73 during the period of 2007-2011 years. This number is comparable with that in advanced countries and much higher than average 7.09 in developing countries as of 2010 (Barro and Lee, 2010).

Growth of government R&D spending has been subject to strong volatility with long term trend standing unchanged around, on average, 2.2% (Figure 4, appendices). Level of R&D intensity with regard to product differentiation has showed little improvement over the period of analysis. On the contrary, import-embodied foreign R&D inflows has noticeable increased and growth has

been steady. Accumulation of foreign R&D intensity in the economy has also demonstrated steady speed until its slowdown during the global financial crisis starting from the third quarter of 2008. Share of high tech capital goods and technology in total imports of Uzbekistan constituted average 59% for the last decade thanks to government policies promoting wide-scale modernization of manufacturing sector.

Growth of FDI inflows and exports averaged around 24% and 13% annually for the last decade. However, scale of FDI flows has been relatively small with respect to the volume of aggregate domestic capital formation – 14%, on average, during 2000-2011. Moreover, role of FDI-related knowledge accumulation in the economy has been relatively weak as increasing portion of the direct investments has been directed to mining and energy related sectors. So to state, roughly half of FDI into Uzbekistan can be classified as source-seeking capital flows disregarding knowledge transmissions. Similarly, even though diversification of exports has been successful and more than 70% of the exports are composed of finished goods, on average, roughly two-third of the country’s exports is classified as low-tech-intensive products. Graphical analysis show that tendencies of import-related knowledge inflows are stronger associated with those of productivity growth rates relative to FDI and exports.

Macroeconomic stability in the country has improved substantially comparing to initial conditions. On the contrary, financial liberalization in terms of domestic credits to private sector as ratio of GDP has maintained stable trend around average 20% - that is significantly low in comparison to that of Korea. Overall, level changes in GDP deflator (DEF – macroeconomic stability variable) and domestic credits to private sector as % of GDP (FL – financial liberalization variable) calibrated from Korean experience of transition seem to demonstrate moderate correlation with knowledge-induced growth in Uzbekistan.

Results of tests for stationarity and cointegration

TFP growth rates are found to be stationary based on Augmented Dickey-Fuller test results. Relatively lower, average 1.14%, growth rates of knowledge-induced productivity growth in Uzbekistan with stationary tendency witnesses that country is in the end of ‘start-up’ and at the beginning of ‘adoption and adaptation’ period of transition into knowledge-based system.

Factors of domestic R&D spending and R&D intensity with regard to product differentiation are also found to be stationary with stronger evidence on the latter. Thereof, initial propositions of both semi-endogenous and Schumpeterian models are not rejected.

ADF tests for stationarity					
TFPG	I(0) [0,03]	R&D_Dom	I(0) [0,004]	R&D_Intens_Dom	I(0) [0,01]
Probabilities are in square brackets					

Cointegration test within Johansen’s methodology does not reject the long-term interrelation between domestic R&D spending and product differentiation in the country.

Johansen Cointegration test for R&D_DOM and TM				
Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.60	17.62	15.49	0.02
At most 1	0.004	0.081	3.84	0.77
Trace test indicates 1 cointegrating eqn(s) at the 0.05 level				

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

The normalized coefficient of cointegration from R&D_DOM to TM is found to be -0.012 (sd=0.002) which is less than negative unity as proposed by Schumpeterian theories. However, statistically significant cointegration coefficient with expected sign provides additional support for the validity of Schumpeterian models of growth for Uzbekistan's transition.

Model estimations and interpretations

Estimation results are summarized in table below. Findings provided important insights into the transition of Uzbekistan into knowledge-based system as well as applicability of policy aspects of Korean experience.

Estimation results (dep. variable - $\Delta \ln A_t$ - TFP Growth)			
	0,082	0,08	
$\Delta \ln X$	(0,055)	(0,61)	
	0,019*	0,02*	
$\ln(X/Q)$	(0,011)	(0,013)	
	0,17***		0,21***
$\Delta \ln X_t^f$	(0,074)		(0,062)
	0,9**		1,1***
$\ln(X/Q)^f$	(0,37)		(0,42)
	1,34*	1,09***	
$\ln S$	(0,69)	(0,52)	
	1,24***		1,2***
$\ln(HC_t)$	(0,03)		(0,24)
		0,24*	0,3*
$\ln(A_t^{World} / A^{UZB}_t)$		(0,13)	(0,16)
		0,96	0,8
$\ln(HC * A_t^{World} / A^{UZB}_t)$		(0,82)	(0,56)
	1,41		1,3
$\ln FL$	(0,85)		(0,79)
	(-1,27)***		(-1,08)***
$\ln(Stab)$	(0,21)		(0,38)
		(-0,003)	0,0018
$\Delta \ln(E_t)$		(0,24)	(0,02)
		(-0,024)	(-0,013)
$\Delta \ln(FDI_t)$		(0,014)	(0,011)
No. of Observations: 76			
Note: Standard errors in parentheses. ***, ** and * imply to significance of estimated coefficients at 1%, 5% and 10% criticals, respectively.			

At the commencement of 'adoption and adaptation' stage of Uzbekistan's transition into knowledge economy, there is no support for semi-endogenous growth propositions whereas little evidence found for Schumpeterian theories. Domestic R&D spending, mostly undertaken by government, does not have statistically significant impact on the productivity growth rates. On the contrary, knowledge-induced growth of the economy is mostly stimulated by inflow of foreign R&D as well as foreign R&D intensities embodied in imports.

Moreover, estimated coefficients for FDI and exports-related knowledge transfers are neither economically nor statistically significant. Furthermore, calibrated policy variables for macroeconomic stability and human capital development do have larger positive and significant marginal level impacts for the productivity growth rates in the country.

However, estimations provided no evidence that development of human capital has been associated with credible absorptive capacity of the economy. This is consistent with the above conclusions that impact of import-embodied knowledge inflows is significant and those of exports and direct investments are not. Therefore, low absorptive capacity has not been capable of acquiring the tacit knowledge and technologies from direct investments and exporting to foreign markets.

Coefficient representing the speed of technological convergence with global frontiers or, equally, speed of transition of the economy into knowledge-based system is found to be statistically significant. However, the estimated speed of transition of Uzbekistan (between 0.24 and 0.3) is found to be noticeably lower than developing countries classified as open (0.6-0.65, Iacopetta, 2012).

Even though impact has been statistically insignificant for productivity growth rates in Uzbekistan, marginal benefit of financial liberalization in the country, in terms of credits provided to private sector, is highly economically significant.

Concluding remarks

Overall findings show that Uzbekistan is at the beginning of ‘adoption and adaptation’ stage of transition into knowledge economy where ‘stage-matching’ calibrations of policies from successful Korean experience are valid to significant extent. Following key conclusions are derived for Uzbekistan from Korean experience validated by the empirical implication of endogenous growth theories.

In the short-run, increasing government R&D expenditures is less likely to stimulate knowledge-induced growth in the country, whereas in the long run R&D spending by the private sector should be encouraged in order to better meet the technology and innovation needs of the manufacturing sector. At the current stage, it would be plausible to stimulate foreign-knowledge inflows by creating more favorable conditions for importers of capital goods, technology and know-hows. Productivity growth through exporting is not expected to yield significant impact on the country’s transition into knowledge economy. Thus trade policies should be strongly outward-looking by providing competitive incentives for exporters in order for them to consciously adopt technologies and innovations as well as invest into long-term productivity means. Impact of FDI related foreign knowledge-inflows into Uzbekistan is more likely to be biased in direction of resource-seeking capitals. Thus, attaching set of ‘technology’ requirements to policies directed to attract FDI flows into the economy would serve to avoid the bias and result in higher pace of knowledge-accumulation in the country.

Human capital development has been an important factor of productivity growth in Uzbekistan with no significant impact on the absorptive capacity of the economy overall. Implementation of policies and creation of institutions linking the education with science and technology would be an important stimulus for accelerating the process of transforming the economy into ‘innovative’

economy. Moreover, improving the overall macroeconomic stability in the country as well as liberalization of the financial system are found to be important sources of promoting R&D acquisition and development for the manufacturing sector. Specifically, monetary policies should be directed to further decrease the aggregate inflation levels and domestic credits to private sector by all means should be stimulated.

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Table 1. Basic statistical properties of selected data (% growth if not otherwise stated)												
	TFPG	DEF_GDP	FL (% of GDP)	HC (av. years of school.)	RD_G	RD_FOREIGN	RI_FOREIGN	S_G	TM_G	EXPORT_G	FDI_G	
Mean	1,14	171,24	19,73		11,66	2,43	0,55	2,80	28,33	25,11	15,50	32,08
Median	1,55	39,57	20,80		11,64	5,11	0,53	3,11	8,59	-0,42	10,84	29,82
Std. Dev.	3,11	304,05	11,82		0,05	14,86	0,18	1,05	63,02	80,01	29,47	47,82
Observations	80	80	80		80	80	80	80	80	80	80	80

Figure 1. TFP Growth rates in Uzbekistan (with Hodrick-Prescott Filter (lambda=100))

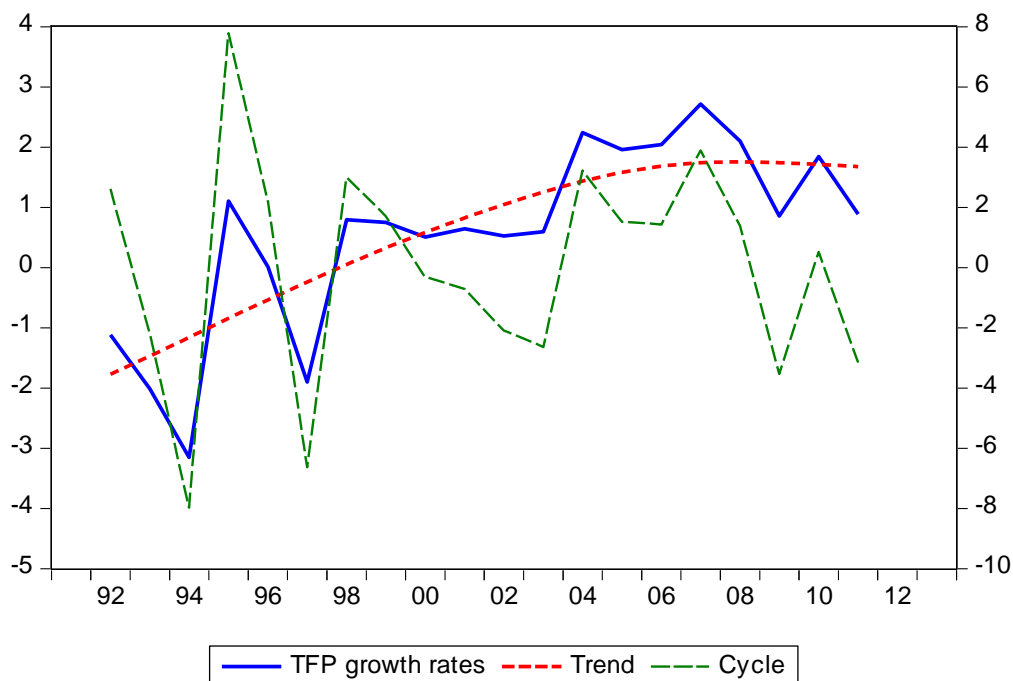


Figure 2. Average years of schooling in Uzbekistan (labor force)

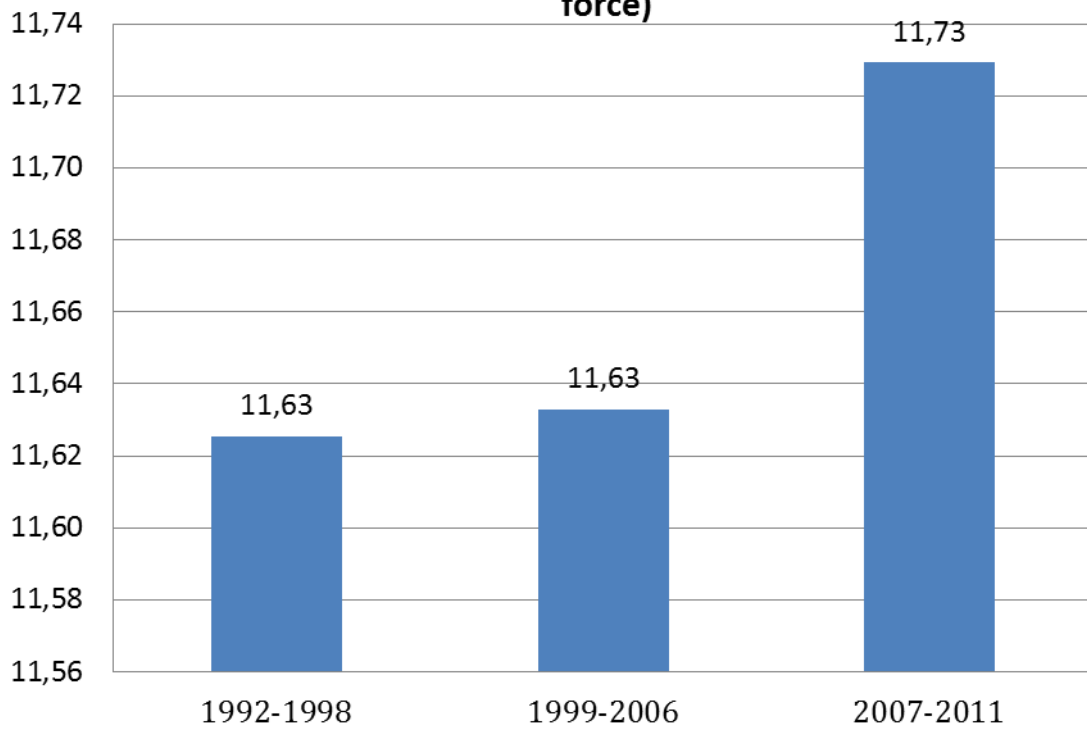


Figure 3. Estimated Contributions of Productivity, Labor and Capital to Total Real Economic Growth

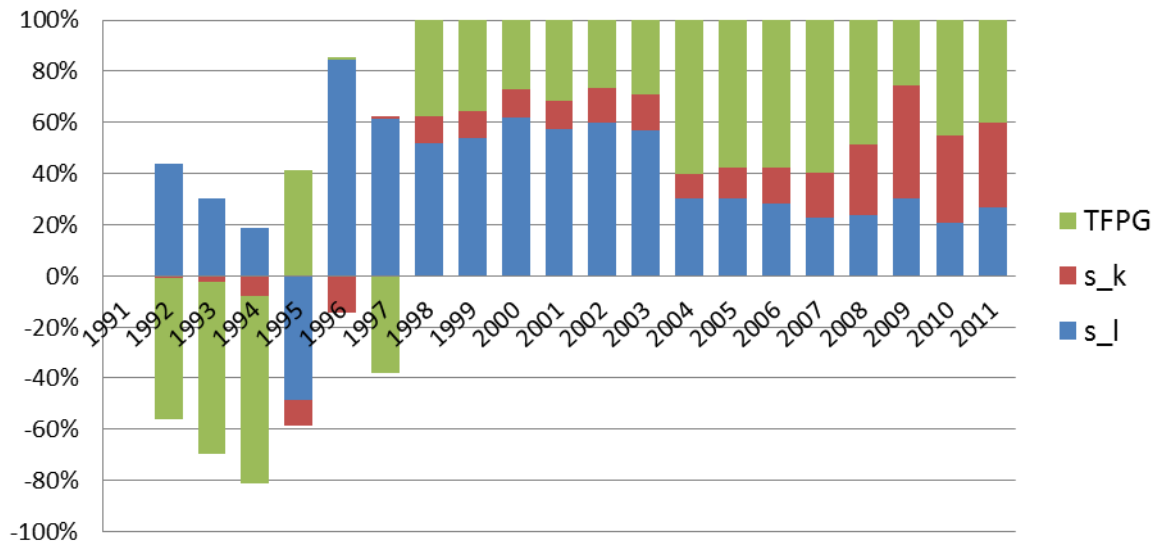


Figure 4. Productivity growth and calibrated policy variables

