

ASSESSMENT OF THE IMPACT OF VENTURE CAPITAL AND PATENTS ON HIGH-TECH EXPORTS

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Key words: venture capital, high-tech exports, patents, econometric models

Introduction On March 10, 2023, the world learned that one of the largest banks in Silicon Valley (SVB), went bankrupt. This bank serves a significant part of American startups, venture capital companies working in the field of IT and healthcare. Undoubtedly, for many years the bank has been a reliable partner and has significantly contributed to the development of venture capital in the United States, which, in turn, has provided great assistance in the development of innovative processes. However, the bank's bankruptcy in no way overshadows the role and importance of venture capital in the development of modern innovation processes. It is impossible to imagine a modern developed economy without innovation and, based on it, the creation of goods and services that are technologically competitive and contain a large share of added value. It is due to these factors that the high level of labor productivity in the economy and the income of the population, and therefore the proper standard of living and high quality of life, are ensured. Naturally, in order to achieve all this, it is necessary to make appropriate investments in the fields of scientific research, education and training systems, technological development and experimentation, infrastructures, and also in appropriate institutional support systems. Especially the former administratively centralized economic systems, which in the last few decades have been making more or less consistent efforts to transform into competitive market and free competition-based economies, are facing serious complications in the above-mentioned arena. It is clearly seen that especially the countries of the former USSR, including the newly independent Republic of Armenia, although they have focused certain resources and efforts on the modernization of the economy and the new technological base in the direction of having competitive economies by international standards, nevertheless, with the features of the general structure of the economy, innovative activity and productivity, with the level of labor productivity, the share of competitive products and services in the total output and export by international standards, they have very modest indicators.

Ensuring a certain level of high-tech export is one of the most important components of forming an innovative system. This problem, depending on the level of development of innovation systems of the countries, is solved by different policies. In this regard, the development of venture capital and the financing of innovative risky projects at

the expense of this source are essential. At the initial stage of formation of venture funds, the precise and coordinated work of all mechanisms of the country's financial system is important. Therefore, in the first part of the research, the dynamics of the availability of venture capital in Armenia were observed, and comparisons were made with the countries in the main foreign economic directions of Armenia. In addition to venture financing, the process of patenting in the country plays a major role in the promotion of high-tech exports. In order to visualize the processes taking place in the latter, the number of patents issued per 1 million population was studied in Armenia and other countries. Based on the study of the dynamics of the above indicators and the combinations carried out for different countries, an econometric model with panel variables was developed for 49 countries and 13 years. With the help of the received econometric model of sufficient quality, it was possible to understand the direction and extent of the influence of the ratio of the availability of venture capital on the one hand, and the number of patents issued per 1 million people on the other hand, on the share of high-tech exports.

Methodology 3 main indicators were considered within the framework of the research: the number of patents issued per 1 million people, the share of high-tech exports in the volume of industrial goods exports, and the index of the availability of venture capital. The number of patents per 1 million people was obtained with the help of own calculations. The index of the availability of venture capital ranges from 1 to 7 points. The closer the actual indicator is to 1, the worse is the situation regarding the availability of venture capital, and the opposite is also true. Statistical data of 2007-2019 were used to study the dynamics of these indicators in Armenia. Next, comparisons were made in three main directions: the South Caucasus and its neighbors, Eastern Europe and the CIS, which includes the EEA member states. The comparisons between the countries included in the above three groups according to the described indicators were carried out as of 2019. This is due to the fact that the statistical data of the availability of venture capital ends in 2019. As a result, it was proposed to study the effect of the ratio of granted patents and the presence of venture capital on the share of high-tech exports with the help of an econometric model with panel variables. Data of 49 countries in the period 2007-2019 were considered in the model. The initial data for more than 100 countries, but based on the fact that there were missing data for various indicators, as a result of statistical data cleaning, 49 countries remained, for which the statistic indicators are available for 2007-2019. Different specifications of models with panel variables were considered, and the one with better statistical properties was selected.

Literature review The possibilities of venture capital are wider than it can be imagined at first glance. They are gaining an increasingly greater role in the world, especially from the point of view of providing financing for innovative high-risk projects. Unfortunately, the process of formation of venture capital does not take place evenly,

significantly limiting the potential for formation of an innovative economy. Many studies have been done on the significance of venture capital, its role and development prospects. In particular, it is noted that venture capital contributes to economic growth in two main ways: firstly by introducing new products and processes to the market, and secondly by developing the absorption capabilities of knowledge generated by private and public research institutes [Pottelsberghe&Astrid, 2004]. It turns out that as a result of the investment of venture capital, the Israeli economy has achieved much higher growth, contributing to securing the leading positions of the country [Zhang et al., 2013].

Many analyzes conducted confirm a positive relationship between venture capital and the coefficient describing innovation development. However, these connections, as shown by the results of the econometric analysis, are quite small, especially for the countries of Central and Southern Europe. Probably, this is due to the fact that the banking system plays a significant role in economies, which strives to reduce the impact of external financing [Leogrande et al., 2021]. Growing economies can benefit from a close relationship between banks and businesses. However, in the case of developed countries, the prospects of financing high-risk productions are not clear. Everyone agrees that Japan has a financial system based on credit, which was acceptable in the immediate post-war economic situation, but the credit financing system is ineffective under current conditions, because a developed economy needs large amounts of venture capital [Pascha& Mocek, 2002]. From this point of view, more plausible are the claims that venture funds, by providing funds to risky research and development projects, contribute to the advancement of innovations, either to effective patenting or to the creation of high-tech products based on it [Greenwood et al., 43].

Many analysts believed that the COVID-19 pandemic would completely destroy the venture capital markets, but these predictions did not materialize globally. The pandemic has only introduced regulation and a shift in venture investment risk to areas where new opportunities are opening up [Ezangina&Malovichko, 2021]. The work has an important role in revealing the connections between the granted patents and the share of high-tech exports in the volume of industrial products exports. In this context, there are works in which a positive relationship between patents and high-tech exports is revealed, but they are conditioned by a number of institutional factors [Malik et al., 2020]. Some others now emphasize that venture financing, patenting of new technologies and product developments are of decisive importance for the competitiveness and market positioning of companies [Webb et al., 1-2]. A number of theoreticians consider the involvement of foreign venture investments in high-tech start-up companies and the export of competitive products created on this basis as one of the main ways of developing small open economies. In particular, this model was successfully launched in Israel [Razin, 2018, 23-24]. The results of a number of studies indicate that investments

in research and development have a greater impact on high-tech exports and success in foreign markets than on productivity in the domestic market [Maican et al., 2020, 25-26]. According to a group of researchers, the volume and intensity of financing of innovative projects are largely determined by the type of innovation they are aimed at. Research shows that risk financing funds and institutions are more likely to finance product and procedural innovations than organizational innovations [Mina et al., 2013, 894]. Studies show that success in innovation is achieved by those countries that build their development strategies by stimulating research and development aimed at creating and securing patents [Pradan et al., 2018, 32]. On the other hand, according to some observations, the macroeconomic effects of venture capital are not very large, in particular, these effects are very modest for economic growth. [Mirna et al., 2022, 13].

Scientific novelty One of the most important tasks of this study is to understand the importance of venture capital in the development of innovative processes. In this context, in Armenia, a number of EAEU, CIS and Eastern European countries, not only the links between venture capital and key innovation indicators have been identified. Also the results of econometric analysis indicate that the development of venture capital contributes to the growth of high-tech exports and patents per 1 million people.

Analysis The following main goals were formulated in the research:

1. Are there any correlations between high-tech exports and granted patents on the one hand, and high-tech exports and the availability of venture capital on the other hand?
2. What direction and size relationships are between the quantities given above?

As part of the first question, the dynamics of the number of patents granted per 1 million people, the share of high-tech exports in industrial exports and the index of venture capital availability for Armenia were considered. Then, in 2019, the behavior of the above indicators in the main external directions of the economy of the Republic of Armenia-the South Caucasus and its closest neighbors, the EAEU, the CIS and Eastern Europe was considered, which allowed certain comparisons to be made. Number of patents issued in Armenia per 1 million people shows the dynamics of high-tech exports share and the index of venture capital availability in the industrial exports (Figure 1). It should be noted that the share of high-tech exports in Armenia in the period under review showed an upward trend. In particular, back in 2007, the share of high-tech exports was 1.1% of industrial exports, and already in 2019, this share reached the level of 9.8%. The interest lies in the fact that for quite a few years in 2009-2014, the share of high-tech exports fluctuated around 1% -3%. This interval actually lasted about 6 years. Then, starting in 2015, there is an immediate transition to the level of 5.7, after that, the share of high-tech exports begins to grow. In 2019, the share of high-tech exports increased by about 2.7 percentage points compared to 2018. In fact, we are seeing an acceleration in the growth of the share of high-tech exports. If in 2007 the number of patents was 55 units, then in 2019 we have a level of about 34 units.

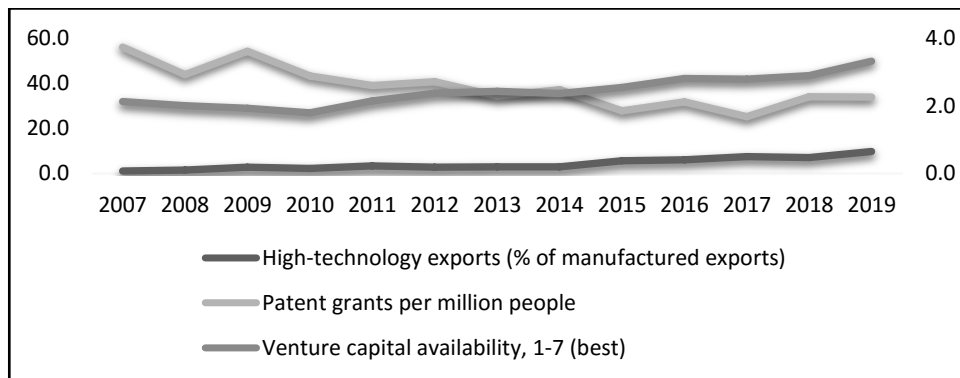


Figure 1. The dynamics of the number of patents granted per 1 million people, the share of high-technology exports in the volumes of industrial exports and the availability of venture capital in RA in the quarters of 2007-2019

(Source: own calculations, WIPO IP Statistics Data Center, High-technology exports (% of manufactured exports) Data (worldbank.org) , WEF_TheGlobalCompetitivenessReport2019.pdf (weforum.org))

The lowest figure was recorded in 2017, when the number of patents issued was about 25 units. The maximum level of patents granted during the period under review was recorded in 2007, amounting to about 56 units. And finally, the index of the availability of venture capital in 2019 was 3.3 points, which is the highest indicator for 2007-2019. The minimum level was observed in 2010 -1.8 points. In the period 2007-2010, there was a decrease in the index of the availability of venture capital, after which, since 2011, there has been an oscillatory increase in the indicator. Since gaining independence, Armenia has established various economic ties in different directions, which are important for the current economy of Armenia. Of these areas, we have identified the most significant - the South Caucasus and its neighbors, Eastern Europe, the EAEU and the CIS. As a result of regional and multilateral cooperation, the main directions important for the economy of Armenia have been formed. Therefore, in terms of the above indicators, combinations of countries included in different directions are important, which will allow us to have certain guidelines for policy implementation. The first region is the South Caucasus and adjacent neighbors. From Figure 2, it can be seen that in terms of the number of patents issued per 1 million people, Russia has an absolute advantage, where the number of patents issued in 2019 amounted to 236 units. Interestingly, in terms of the number of patents, Armenia is in second place -34 units, and Iran is in third place -33 units. In terms of the number of patents granted, the minimum level is fixed in Azerbaijan - 10 points. In terms of high-tech exports in 2019, Russia, Armenia, Turkey and Azerbaijan are leading in the region by 13%, 10%, respectively, 5% and 5%. According to the index of availability of venture capital, Azerbaijan is in the lead-4 points. Armenia, Russia, Georgia and Turkey recorded a 3-point level of the venture capital index. In Iran, the index is fixed at 2 points.

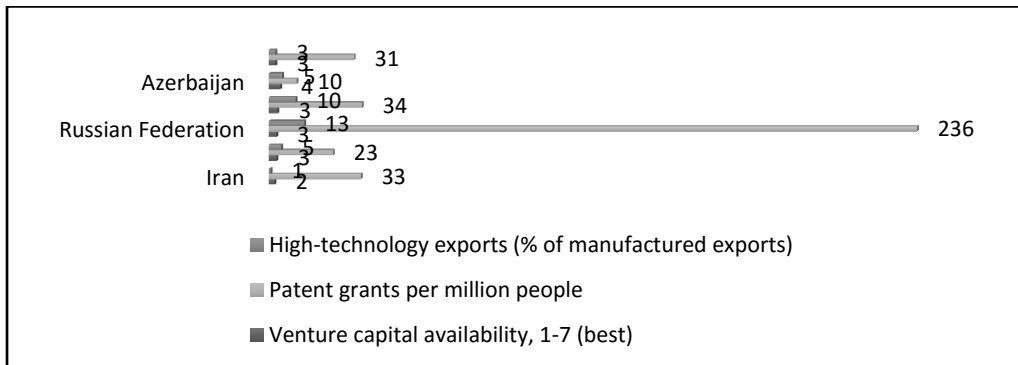


Figure 2. The dynamics of the number of patents granted per 1 million people, the share of high-technology exports in industrial exports and the availability of venture capital in the South Caucasus and neighboring countries in 2019

(Source: own calculations, WIPO IP Statistics Data Center, High-technology exports (% of manufactured exports) Data (worldbank.org) , WEF_TheGlobalCompetitivenessReport2019.pdf (weforum.org))

The next region we are interested in is Eastern Europe .

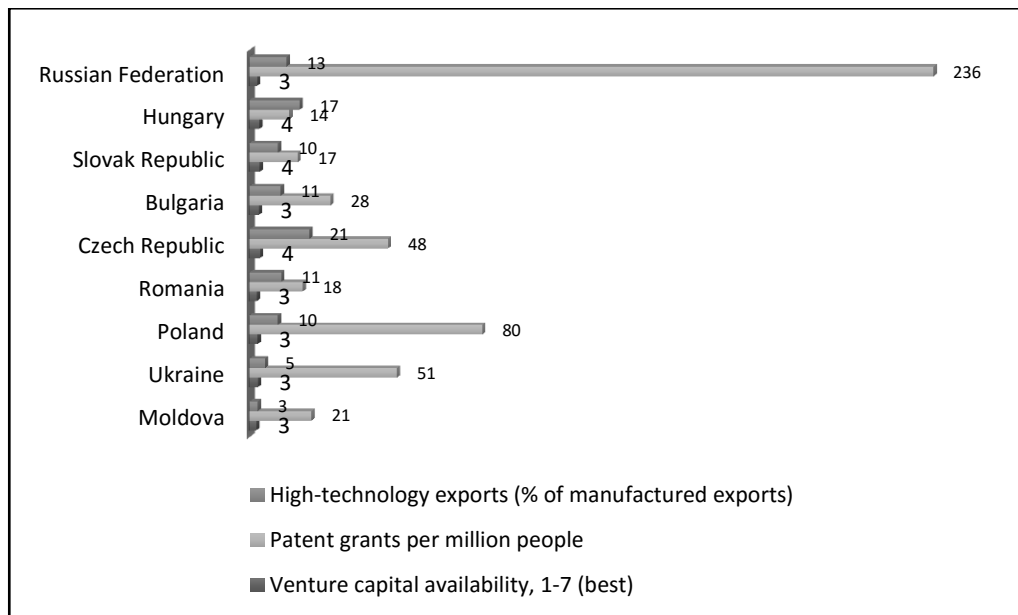


Figure 3. The dynamics of the number of patents granted per 1 million people, the share of high-technology exports in industrial exports and the availability of venture capital in the South Caucasus and neighboring countries in 2019

(Source: own calculations, WIPO IP Statistics Data Center, High-technology exports (% of manufactured exports) Data (worldbank.org) , WEF_TheGlobalCompetitivenessReport2019.pdf (weforum.org))

In terms of the number of patents issued per 1 million people in Eastern Europe, Russia is again the leader. Poland is in second place, where the number of patents

granted reaches 80 units. The next place is occupied by Ukraine with an indicator of 51 points. Ukraine is followed by the Czech Republic, where, as of 2019, the number of patents per 1 million people amounted to 48 units. The minimum level in Hungary is 14 points. The Czech Republic and Hungary are the leaders in terms of the share of high-tech exports, where the share of exports was 21% and 17%, respectively. Russia ranks third in terms of exports, while Moldova has a minimum share of 3%. The Czech Republic, Slovakia and Hungary are the first in the index of availability of venture capital (4 points). The lowest level of venture capital in Eastern Europe is 3 points.

And finally, let's consider the situation in the CIS, which also includes EAEU members Russia, Armenia, Belarus, Kazakhstan and Kyrgyzstan .

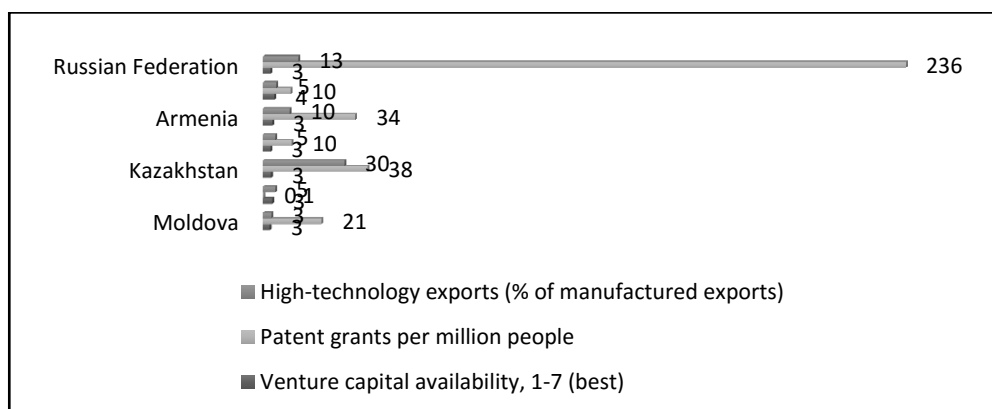


Figure 4. Dynamics of the number of patents per 1 million people, the share of high-tech exports in the volume of industrial exports and the index of the availability of venture capital in the CIS in 2019

(Source: own calculations, WIPO IP Statistics Data Center , High-technology exports (% of manufactured exports) | Data (worldbank.org) , WEF_TheGlobalCompetitivenessReport2019.pdf (weforum.org))

According to the number of patents issued in the CIS for 1 million people, the Russian Federation is the leader. Azerbaijan has the highest rating on the index of availability of venture capital. In the volume of exports of industrial products, Kazakhstan occupies the absolute maximum share of exports of high-tech products-30%. In the CIS, according to the index of the availability of venture capital is at least 3 points. The number of patents issued in Tajikistan for 1 million people is almost close to zero. Kazakhstan and Armenia are in second and third place in terms of the number of patents granted. Armenia ranks third in terms of high-tech exports 10%.

Modeling The above analysis showed that there are certain links between the share of high-tech exports and patents granted on the one hand, as well as the index of high-tech exports and the availability of venture capital on the other. To assess these relation-

ships and, consequently, to answer the second question posed above, an econometric model with the following panel variables was studied [Eliseev, 2021].

$$EXP_{it} = \alpha_0 + \alpha_1 \cdot VCA_{it} + \alpha_2 \cdot PAT_{it} + \varepsilon_{it} (1)$$

where

EXP_{it} – is the share of high-tech exports of the i-th country in the volume of exports of industrial products in the t-th year ,

VCA_{it} – is the coefficient of venture capital availability of country i in year t,

PAT_{it} – is the number of patents granted per 1 million people in country i in year t,

$\alpha_0, \alpha_1, \alpha_2$ – are the unknown parameters of the model,

ε_{it} – is the random error of the model,

i – is the country index. Moreover, $i = \overline{1,49}$

t – is the index of the year. Moreover $t = \overline{2007,2019}$.

In the model, the coefficients α_1 and α_2 are of interest, indicating the direction and magnitude of the impact, respectively, the index of availability of venture capital and patents for the share of high-tech exports per 1 million people. To select the optimal model, they were evaluated according to various specifications. The output gave satisfactory results using an econometric model of separated variables, which was evaluated using the least squares method. As a result, the following results were obtained.

Table 1. Estimated econometric model results in terms of key variables

Dependent variable: log(EXP)		
Variable:	coefficient:	level of significance:
log(VCA)	1.1:	***
log(PAT)	0.2:	***
R-squared	0.62	

The evaluation results show that:

1. a 1% increase in venture capital, ceteris paribus, leads to an average 1.1% increase in the share of high-tech exports;
2. a 1% increase in patents granted per 1 million people, ceteris paribus, leads to an increase in the share of high-tech exports by 0.2% on average.

Conclusion One of the main conclusions of the conducted research is that in modern conditions, qualitative and development resources, particularly venture capital and issued patents, play the main role in the movement of economic growth and high-tech export factors. During the analysis, in order to reveal the connections between the indicators described above, an econometric model with panel variables was put forward, after its evaluation, the following conclusions were made:

1. a 1% increase in venture capital, ceteris paribus, leads to an average 1.1% increase in the share of high-tech exports;
2. A 1% increase in patents granted per 1 million people, other things being equal, leads to an increase in the share of high-tech exports by 0.2% on average.

Venture financing is a unique mechanism through which it is possible to provide the "road map" of business promotion and its expansion from knowledge and development to the market. In our opinion, the development of the venture system is more effective if it is institutionalized in a proper way, that is, it is provided with a proper legal basis, unique mechanisms for the protection and regulation of intellectual property, general and selective economic policy tools and levers.

The results of the study indicate that high-tech exports with a large share of added value have a significant impact on venture investments, access to venture capital, R&D expenses/GDP ratio, as well as volume indicators of patents. In this context, RA's economic policy toolkit should be aimed at improving the above-mentioned indicators. In particular, it refers to the reservation and proper protection of intellectual property rights.

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Assessment of the impact of Venture Capital and Patents on High-tech exports¹

Key words: venture capital, high-tech exports, patents, econometric models

Ensuring appropriate financial flows is of key importance in the development of innovation processes. This study describes the importance of venture capital, one of the sources of financing innovative processes and the basics of its formation, based on the analysis conducted by many authors. Particular attention was paid to the dynamics of high-tech exports, patents granted and the index of venture capital availability in Armenia and neighboring countries, Eastern Europe. Using econometric models, the following hypotheses underlying the study were tested: Are there dependencies between high-tech exports and patents granted, on the one hand, and the index of availability of venture capital and high-tech exports, on the other? What is the direction and amplitude of above-mentioned relations? As a result of the study, it was shown that an increase in venture capital, other things being equal, leads to an increase in the share of high-tech, while an increase in patents granted also positively affects the dynamics of the share of *high-tech exports*.

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