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Testing big push theory in an experimental setting

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1 Introduction

Big push theory originated with (Rosenstein-Rodan, 1943). The theory proposes that developing countries require large-scale simultaneous investment in modern industry in order to emerge from a poverty trap - incremental investment is at best inefficient and at worst ineffective. The government is perceived as playing an important coordination role in the development process, for example, by providing complementary infrastructure. Government support is integral to the theory since the scale of industrialisation envisaged by big push models of development is likely beyond the capability of the private sector, particularly in the case of investment in overhead capital. The big push theory has been applied to many settings, including the transition from agriculture to manufacturing and the establishment of new industries based on modern technology.[1]

Big push theory relates to the poverty trap literature, which seeks to explain why countries exhibit slow growth despite low levels of income per capita. The dominant poverty trap models revolve around multiple dynamic equilibria. In the context of industry, multiplicity of equilibria emerges because of a coordination problem in industrial activity, resulting from interdependence in the production process. One firm's decision as to whether to industrialise will depend on its expectations of what other firms will do. Therefore, even though an economy may possess the human capital resources to move from a low-income equilibrium to a higher income equilibrium, this may not occur because firms or investors make decisions in a decentralised manner. The role of development policy, therefore, is to create self-fulfilling expectations that drive the economy towards the Pareto efficient equilibrium.

We chose to study big push theory because of a relatively recent revival of interest in the theory. The theory fell out of favour in the 1970s and 1980s, following disappointing results from public investment, part-funded by foreign aid, in Africa. However, in recent years, Jeffrey Sachs, a prominent development economist, has advocated for a significant increase in foreign aid to fund large-scale investment in developing countries, in particular in health and education.

(Lucas, 1986) suggests the experimental setting is an ideal environment for cases in which economic theory does not provide an indication as to which equilibria agents will coordinate upon. Furthermore, identifying the causal impact of 'big push' policies on growth is difficult because policies are often implemented as part of a wider package of institutional and eco-

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nomic reforms, such as in South Korea in the 1960s, making it difficult to isolate the influence of a particular change. As such, there is very little empirical evidence for big push theory. In this paper, we make exogenous changes to the macroeconomic environment, allowing us to clearly identify the impact of government intervention on outcomes of interest.

We investigate whether a big push policy, framed as government investment in complementary infrastructure, is capable of driving an economy out of a poverty trap in a laboratory setting. Given contention in the literature surrounding the scale of investment needed to facilitate an economy breaking out of a poverty trap, we test whether differences in the size of government intervention affects the likelihood the economy converges to the Pareto efficient equilibrium.

We find some evidence to support the idea that a big push can help agents coordinate on a Pareto efficient equilibrium. However, given our experimental parameters, we don't find any difference in the effectiveness of a big push based on the size of the government intervention.

2 Literature review

(Rosenstein-Rodan, 1943) advocated for a big push in developing countries because of indivisibilities in production. (Rosenstein-Rodan, 1943) identified three indivisibilities in underdeveloped countries - indivisibility in the production function, indivisibility of demand, and indivisibility in the supply of savings. Indivisibilities create external economies of scale, which justify a big push, since individual agents will not consider external economies when making investment decisions independently. Therefore, investments that are profitable in terms of social marginal net product might not be undertaken since they are not profitable in terms of private marginal net product. However, due to external economies, simultaneous investment might make individual investments profitable and therefore government policy to encourage simultaneous investment might be able to spur rapid economic growth.

(Murphy et al., 1989) formalised big-push theory. In their model of infrastructure investment (which most closely aligns with what we study in this paper) they focus on construction of a railroad, although the theory is applicable to other infrastructure projects The railroad will be profitable ex-post if firms industrialise post-construction, but firms will only wish to industrialise if the railroad is built. There exists an equilibrium in which the railroad is not built because of uncertainty about whether firms will industrialise and become users of the railroad. The authors suggest the multiple equilibria phenomenon provides a justification for government to both coordinate private investment and subsidise the construction of infrastructure. The authors note that power stations, roads and airports are also likely to require government support.

(Rodrik, 1996) establishes a model with two final-goods sectors, 'low-tech' and 'high-tech'. High-tech production requires a range of differentiated intermediate inputs that are produced under increasing returns to scale and are non-tradable. For the high-tech final goods-sector to be viable, a sufficiently large number of intermediates need to be produced domestically. (Rodrik, 1996) incorporates a parameter representing the skill level of the workforce. He shows that when the skill-level of the workforce lies within a certain range, the economy may get stuck in the low-tech equilibrium, even when the high-tech equilibrium is viable. This occurs because when the economy is specialised in the low-tech sector, it will not be profitable for an individual firm to enter the high-tech (or intermediate goods) sector at the market factor prices. Rodrik considers many East Asian economies to have been in this situation around 1960 - at this time, these countries had high levels of educational attainment given their per capita income levels. Rodrik suggests that the role played by governments in Japan, South Korea and Taiwan "coordinating, subsidizing and guiding private investment decisions" were integral to their economic development.

Very few papers in the big-push literature extend beyond theoretical models to apply big-push dynamics to real-world growth experiences. (Bateman et al., 2009) is one notable exception. The authors argue that large-scale public investments in the American South during the Great Depression and the Second World War helped the region break free from a "low income, low productivity trap". They find that a state's growth in public capital between 1933 and 1945 had a strongly positive impact on growth in value added per capita in manufacturing between 1947 and 1954. In their regression framework, the author's account for alternative explanations for the growth in manufacturing, such as the presence of lower wages in the South and differences in union density. Furthermore, using a 1949 National Planning Association survey, the authors find evidence that locational decisions of industrial firms moving to the South in the three years following the Second World War were consistent with big-push dynamics. Many firms, for example, cited improvements in the transportation system and an enlarged market (resulting from other firms locating in the region) as factors behind their decision to open a plant in the region.

Contrary to big push theory, (Kraay and McKenzie, 2014) argue that there is very little evidence for the existence of poverty-traps at the macro-level. They note that the mean rate of growth in real GDP per capita from 1960-2010 among the poorest quintile of countries in 1960 was similar to that of the richest quintile. However, the author's also show that growth in real GDP per capita was slowest in the second poorest group, at just 0.9% per annum, which does suggest a group of countries struggling to undergo an economic transition. (Kraay and McKenzie, 2014) also cast doubt on the idea of a big push. They cite evidence from (Caucutt and Kumar, 2008), who find that calibrations of multiple equilibria, using a Murphy-Shleifer-Vishny model, don't fit conditions in Sub-Saharan Africa. Furthermore, they find that a one-time subsidy of only around 5% of fixed costs of investment is required to avoid a stagnant growth equilibrium, a modest intervention in the context of big push theory, which focuses on large-scale government intervention.

In addition to this, (Hausmann et al., 2005) find that there is no stable relationship over time between countries' income level and the likelihood of a growth acceleration, which is inconsistent with the theory of poverty traps, which suggests that countries emerging from poverty traps should experience rapid economic growth.

There exists a limited literature covering poverty traps in an experimental environment. (Capra et al., 2009) focus on the impact of institutions on coordination. They implement an experiment in which subjects allocate income between consumption and saving each period. This decision determines each player's capital stock in the next period. Each period, prior to making the consumption/saving decision, agents were also able to sell capital in a call market. The authors implement a threshold level of the aggregate capital stock above which each agent converted capital to output with a higher level of productivity. They find that in the baseline treatment, economies converge to the poverty trap equilibrium, however, communication (prior to the call market) and voting (on consumption/saving decisions) treatments, respectively, increased the probability of escaping the poverty trap. The most effective treatment was a 'hybrid' treatment combining communication and voting, in which participants consistently escaped the poverty trap.

We contribute to the literature with the first, to the best of our knowledge, experiment testing the big push theory of development. Through our experiment, we extend the experimental literature on poverty traps to consider the role of government in a market economy, a critical research area.

3 Experimental design

Similarly to (Rodrik, 1996), we model an economy in which there are two different equilibria - a low-tech equilibrium and a high-tech equilibrium. In our set-up, investors choose how to split their endowment between investment in a low-tech industry and a high-tech industry, where we use the term industry to encompass a multitude of sectors.

We endowed each investor with 100 to split between the high-tech sector and the low-tech sector, with no outside option. We allowed the investor's endowment to accumulate across rounds. Therefore, an investor started each round with their initial endowment plus the value of accumulated profit (or loss) from previous rounds. We feel this is the most realistic way to model the big push phenomenon - in a real-world context, repeated failed attempts at economic transformation are likely to result in firms suffering large losses, making it financially more difficult to transition in the future. On the other hand, steady economic growth may reduce the difficulty associated with making the leap between a low-income equilibrium and a higher income equilibrium. Figure 1 in the appendix details the instructions of our game. All figures referenced in the paper are included in the appendix.

The participants were informed that the session would be played over an indefinite period, lasting no more than 30 minutes. For time efficiency purposes, we implemented a random ending between rounds 7 and 10. Given the economy is an infinite construct, we wanted agents to behave as if the game would be played infinitely. As outlined by (Capra et al., 2009), in theory, if agents are risk-neutral, a random ending should induce behaviour which is theoretically equivalent to an infinite time horizon with discounting.

We model the low-tech sector as providing a constant, sure return of 3% on investment. In our study we focus on indivisibilities in the production process. As a consequence of production indivisibilities and interdependence in the production process, profitability in the high-tech sector depends on its size. Therefore, we impose a threshold for the total investment by all players below which the return from investing in the high-tech sector is negative (-5%). Above this threshold, the rate of return is increasing in the total level of investment in the high-tech sector. Figure 2 displays the payoff structure in the ‘control’ game, in which there is no government intervention.

The game was coded and fully designed using O-tree (Chen et al., 2016). To make an investment decision, the participant needed to enter a value for the high-tech sector - investment in the low-tech sector would be automatically calculated (to reduce cognitive cost associated with making calculations), and then submit their decision by pressing ’next’. Each participant had a time limit of two minutes in which to make an investment decision, otherwise O-tree automatically allocated all of their endowment to the low-tech sector. In the case that the participant had entered a value for high-tech investment in the available space, but did not submit before the time limit, that value was assumed to be reflective of their investment preferences and O-tree submitted that value as their high-tech investment.

After making an investment decision, the participant passed to a waiting page, where they remained until all participants had finished the round. On the waiting page, participants were presented with an interesting fact, accompanied by a photo (depicted in Figure 3). This was designed to keep the participant engaged.

After all participants had submitted their investment decision, participants passed to a returns screen (shown in Figure 4) in which they were informed of the total investment in the high-tech sector by all players, and the payoff from their personal investment in the high-tech sector. Participants were not able to see the individual investment of the other players and were not aware of the identity of the other players involved in their session. We wanted to mimic a scenario in which there are too many market participants for any one investor to be able to assess the risk preferences of all other market participants, which we feel is representative of the dynamics of large industries.

We have three main treatments - no government intervention, low government intervention and high government intervention. In the paper, we refer to the latter two together as intervention treatments. In these treatments, a government intervention, occurring at a random time between rounds 4 and 7, shifted the payoff structure associated with investment in the high-tech sector. Importantly, the intervention lowers the threshold level of total investment in the high-tech sector below which the return on investment is negative. Participants were informed that the government had invested in transport and communications infrastructure (two sectors commonly identified in the big push literature as being key sectors for big-push dynamics) which was complementary to production only in the high-tech sector. The text is displayed in Figures 5 and 6, which also display the payoffs following intervention in the high-level of government intervention and low-level of government intervention game, respectively.

Our experiment followed a between-subjects design. We ran a total of 10 sessions, split across 6 different treatments. The additional three treatments consisted of a constant endowment game with a low level of government intervention and two games which mirrored the post-intervention payoffs of the high and low intervention games but with no government intervention (payoffs implemented throughout every round of the game).

Two sessions utilising the low government intervention game were conducted in the out-of-class group for two reasons. Firstly, the results of the first out-of-class intervention game were markedly different from the in-class group. Secondly, a famous Indian film star (many of the participants in the 'out-of-class low government intervention 1' session were Indian) died during the session. We feel that this may have distracted the participants, and more importantly, induced a negative mood. Given evidence negative mood can induce greater risk aversion e.g. (Drichoutis and Nayga Jr, 2013) we felt it appropriate to run an additional session in which we did not expect another external shock to mood.

Subjects were either members of the Barcelona Graduate School of Economics (BGSE) Experimental Economics class or contacts of the experimenters. A total of 63 subjects participated in our experiment. The results from participants in the BGSE Experimental Economics class, exposed to the three main treatments, constitute the 'in-class' group. Our in-class group is composed of 21 people, with an average age of 24, 10 of whom were female. We refer to experiments conducted outside of class as the ‘out-of-class’ group. In total there were 42 participants in the out-of-class group, with an average age of 30 and 9 females. Only three of these subjects had taken an experimental economics class. The majority of subjects in the out-of-class group were not students. Our analysis was conducted separately on the out-of-class and in-class groups, since results and demographic characteristics of the two groups were judged to differ too much to pool the data.

4 Competitive equilibrium and hypotheses

We consider that our economy has two stable equilibria. We believe each economy would converge to either a high-tech equilibrium or a low-tech equilibrium if the game was played over a longer time horizon. The high-tech equilibrium, a Pareto efficient outcome, involves every player investing their whole endowment in the high-tech sector, thus generating the highest possible payoff for each player. On the other hand, in the low-tech equilibrium each player invests all their endowment in the low-tech sector.

Our game closely mirrors a threshold public good game. Despite behaviour in the standard public good game typically converging toward the Nash equilibrium of zero contributions, (Gächter et al., 2017) find that accumulating endowments allow for a higher level of cooperation (20-60% contribution rates). Furthermore, they find that contributions are increasing over time. On the other hand, the contribution rate decreases at first, then stabilises from period 6 at a constant level of income.

We chose to focus on investment rates in the high-tech sector (equivalent to the contribution rate) in most of our analysis because we expect nominal investment in the high-tech sector to increase if agents accumulate wealth, which occurred in most of our sessions. Investment rates are more appropriate since we are interested in whether agents achieve close to full cooperation on one of the two equilibrium outcomes, not simply whether the high-tech sector is profitable.

However, given our payoff structure incorporates both a threshold below which agents lose money from investing in the high-tech sector and increasing returns in the high-tech sector, unlike (Gächter et al., 2017), we do not expect that investment rates will stabilise in any of our sessions. Instead, we expect that each economy will converge toward one of our two equilibria. Specifically, we outline our hypotheses below.

H1: In treatments with a government intervention, investment rates in the high-tech sector will be higher in the government intervention round than in the previous round
H2: Intervention games will converge towards the high-tech equilibrium, whereas, participants in the no government intervention game will remain in a poverty trap

H3: Final-round investment rates in the high-tech sector will be greater in the treatment with a high-level of government intervention than in the game with a lower level of government intervention.

5 Results

5.1 Does big push work?

Figure 7 shows mean investment rates in the rounds surrounding the intervention in all sessions in which government intervention was present. The chart suggests that the government intervention made an immediate difference to investment rates in all but two of these sessions. In the 'in-class low government intervention' session, agents had already begun cooperating on the Pareto efficient equilibrium prior to the intervention and hence there was little scope for the intervention to have an effect. The second case is the session labelled 'out-of-class low government intervention 1', given by the orange bars, in which the intervention was unable to facilitate cooperation, although attempts to cooperate on the high-tech equilibrium were limited throughout this game.

Due to a limited number of observations (at most 7 per session) and non-normality of the dependent variable, we ran a one-tailed Wilcoxon signed rank test for whether investment rates in the intervention round were higher than the round prior to intervention. In the 'out-of-class low government intervention 1' session, the intervention did not make a significant difference to investment rates in the high-tech sector, which is to be expected given the evidence in Figure G. The results of this session are also in line with the idea that factors outside the control of the experimenters (the death of an Indian film star) induced negative mood, which may have led participants to become more risk-averse.

The intervention had a statistically significant effect on investment rates in the 'in-class high government intervention' session ($p = 0.028$, standardised effect size $= 0.78$) and in the 'out-of-class constant endowment' session ($p = 0.017$, standardised effect size $= 0.87$). In the former case, investment rates had appeared to be converging towards the low-tech equilibrium. This trend was interrupted by the intervention, which resulted in an increase in the mean investment rate in the high-tech sector of around 50 percentage points between the round prior to intervention and the intervention round. Unfortunately, there were insufficient observations, once accounting for participants who did not change their investment rate between the round prior to intervention and the intervention round, to test the effect of intervention in the 'in-class low government intervention' or 'out-of-class low government intervention 2' sessions.

Overall, we find some evidence in favour of H1, however, the evidence is not conclusive and testing this hypothesis is restricted by the size of our sample.

5.2 Which economies escaped the poverty trap?

We also assess the effectiveness of government intervention by comparing each session against a hypothetical scenario in which each agent invests all their money in the low-tech sector each period. In this case, the sum of endowments (of all players) would grow by 3% each period. This is represented by the black line in Figure 8. We classify any economy in which the sum of endowments is equal to or lower than the low-tech equilibrium to be stuck in a poverty trap.

Figure 8 shows that two economies break out of the poverty trap in the early rounds - ‘in-class low government intervention’ and ‘out-of-class low government intervention 2’. Both of these economies converged to the high-tech equilibrium, with mean contribution rates in the final round of each session of 99% and 94%, respectively, as shown in Figure 9. However, cooperation on the high-tech equilibrium had largely been established in both these sessions prior to the intervention, therefore, they provide at best limited support for big push theory.

By the final round of the game, the sum of endowments in the ‘in-class high government intervention’ session reached a level higher than that associated with the projected low-tech equilibrium. Given the economy converged to the high-tech equilibrium (93% investment rate in the high-tech sector in the final round), we also class this economy as escaping the poverty trap. In this case, the sum of endowments was actually lowest out of all sessions until the intervention round (represented by a square), after which it rose rapidly. The results from this group provide strong evidence in support of big-push theory.

Furthermore, in a multiple regression analysis, controlling for age, gender and nationality, displayed in Figure 10 for the in-class group, we find that mean investment rates are statistically significantly higher (at the 1% level) in intervention games compared to the no government intervention game. In Figure 11, we show the equivalent regression for the out-of-class group, but the low government intervention sessions are our reference group in this case. We find that investment rates in the high-tech sector are significantly lower in the ’out-of-class no government intervention’ session, compared to the low government intervention sessions.

Lastly, using a Mann-Whitney U test, we find a highly significant difference in the mean investment rate (averaged across all players) between the ‘in-class low government intervention’ session and the ‘in-class no government intervention’ session ($p = 0.000$). We also find a significant difference between the ‘in-class high government intervention’ session and the no government intervention game ($p = 0.003$).

Taken together, the forecasting analysis, the regression analysis and our statistical tests provide evidence that a big push can, at the very least, help sustain cooperation. Final round investment rates (in the high-tech sector) were highest in intervention games, whilst those economies which most clearly escaped the poverty trap were all intervention games. We therefore conclude that our second hypothesis is likely to be true, though we would like to have had additional sessions for each of our main treatments in order to test the robustness of this finding.

5.3 Does the size of the intervention make a difference?

Looking at the in-class sample, it is not possible to assess the impact of the size of the government intervention on the effectiveness of a big push policy. Low intervention and high intervention groups are incomparable because the low intervention group began cooperating on the high-tech equilibrium prior to the intervention round. In this session, first round investment was unusually high, at 61% (see Figure 9) . As a result, this was the only session in which investment in the high-tech sector during the first round did not yield a negative return, thus making cooperation on the Pareto efficient equilibrium relatively straightforward thereafter. On the other hand, investment rates in the high government intervention game had been converging towards the low-tech equilibrium prior to intervention. Furthermore, both economies converged towards full cooperation (defined as having a mean high-tech sector investment rate of around 100%) on the high-tech equilibrium, making it even more difficult to distinguish how the impact of an intervention varies according to its size.

Unfortunately, we don't have an out-of-class sample for the high government intervention game with which to compare our low government intervention sessions against. Therefore, we conclude that there is no evidence in favour of H3, considering our in-class and out-of-class sample.

5.4 Determinants of high-tech investment rates

We conducted a multiple regression analysis for both the in-class and out-of-class groups to investigate the determinants of individual investment rates in the high-tech sector, displayed in Figures 10 and 11. We find that there are no gender differences in investment rates. This is perhaps surprising given that in the Gneezy and Potters risk elicitation task, framed as an investment, females are consistently more risk-averse than men (Crosetto and Filippin, 2016). However, given the structure of the game, the participants, especially those familiar with the experimental economics literature, might have interpreted the game as a public good game. There is little evidence for gender differences in contributions in public goods games using mixed groups.

In the out-of-class groups we find that nationality is an important determinant of mean investment rates in the high-tech sector. Indians invested significantly less than British people, the latter being our reference group because it was the modal nationality of participants in the out-of-class sample. Indians also invest significantly less than individuals from our composite group of nationalities if this is used as the reference group. We may be capturing a cultural aversion to risk and/or a lack of trust among Indian nationals, though, unfortunately, we are not able to differentiate between these two channels.

6 Robustness checks

6.1 The accumulation effect

We created an additional treatment, conducted with our out-of-class group, to identify whether our results are driven by an accumulation effect. Given that the payoff structure remained constant until the intervention, after which the intervention payoffs were present until the end of the game, cooperation may have been attained in our intervention games primarily because agents were able to accumulate wealth. If the sum of endowments increases across rounds, this implies that the investment rate (averaged across all the players) needed to reach the high-tech threshold (or the bands associated with higher returns) is lower. The additional treatment was a constant endowment game - a game with a low level of government intervention but each player's endowment was reset to 100 in every period.

Returning to Figure 7, in the 'out-of-class constant endowment (low intervention)' game we observe a sharp increase in mean investment in the high-tech sector in the intervention round compared to the previous round (an increase of around 22 percentage points). This suggests higher investment rates in the intervention games are at least partly driven by the intervention. However, the regression analysis in Figure 11 does indicate that investment rates were lower in this game compared to the low government intervention sessions, suggesting accumulation may have played a role in our results. Investment rates are not statistically significantly lower, however, reinforcing our belief that our results are not driven by an accumulation effect. We would, however, like to have been able to run additional sessions using this structure, including a high government intervention game, in order to check the robustness of this finding. This was not possible because of a limited pool of contacts and difficulties the experimenters experienced organising a time for 7 people to participate in a session.

6.2 The intervention effect

We conducted two final treatments using our out-of-class sample. In the 'no intervention low returns' game, we use the payoff structure associated with post-intervention payoffs in the low government intervention game, but the payoff structure is present from the first round and there is no intervention. The 'no intervention high returns' game is equivalent for the high government intervention game. We seek to explore whether the government intervention affects the investor's approach to the game in a way that extends beyond the reduction in risk associated with the changing payoffs.

The evidence on the psychological effect of the intervention is mixed when looking at sessions with 'low' returns. Figure 12 compares the out-of-class low government intervention sessions to the 'no intervention low returns' session. Comparing the 'out-of-class low government intervention 2' session to the 'out-of-class no intervention with low returns' session, we see that the two economies take very different paths after round 4 - in the 'out-of-class low government intervention' session investment in the high-tech sector peaks in round 4 (as a %), declining thereafter until round 9. On the other hand, in round 4 of the 'out-of-class low government intervention 2' session, government intervention drives the economy towards the high-tech equilibrium, where it remains until the end of the game. There is, however, no evidence of a strategic shift in the 'out-of-class low government intervention 1' session, in which the intervention did not appear to have any long-term effect on investment rates. Pooling both games together, there is essentially no difference in investment rates in the high-tech sector between the low government intervention sessions and the 'no intervention low returns' game (see the regression analysis in Figure 11).

Unfortunately, we did not run a high government intervention session with the out-of-class group. We therefore choose to compare the 'no intervention high returns' game with the in-class high government intervention game, as displayed in Figure 13. We caution that the reader should not rely heavily on this analysis, since the in-class and out-of-class group have quite different demographics and thus may not be directly comparable. Despite this, given the two games follow similar trends, we find them useful to compare. Investment rates in the first round are similar in both games, despite the significantly lower payoffs in round 1 of the high government intervention game. Both sessions show the same initial downward trend in investment rates, much like in a typical public goods game. It appears quite likely this trend would have continued in the no government intervention game. However, investment rates in the 'in-class high government intervention' session increased markedly in the intervention round (5), before rising towards full cooperation on the high-tech equilibrium, something we don't witness in the comparison group. Overall, a comparison of these two sessions suggests a profound psychological impact of the intervention on risk appetite.

Overall, the evidence from these games regarding the psychological effect of an intervention is inconclusive, though we believe the results suggest interventions had a larger effect on the strategy and risk appetite of the players than can be accounted for by the change in payoffs. The payoffs are more favourable to investment in the high-tech sector in the games without an intervention, and hence we should expect higher mean investment rates in the high-tech sector in these games. However, we find much higher final round contributions in the 'in-class high government intervention' and 'out-of-class low government intervention

2' sessions compared to the 'no intervention high returns' and 'no intervention low returns' games, respectively.

7 Discussion

We find some evidence that a big push policy plays a role in enhancing coordination on the Pareto efficient equilibrium. Our analysis, however, is limited by a small sample size, which made it difficult to conduct robust statistical tests measuring the impact of the intervention on investment rates in the high-tech sector. This was as a result of both our design structure and our results. We had multiple treatments and only 7 players in each session. Furthermore, differences between in-class and out-of-class groups prevented pooling of the data.

Given a larger sample, the authors would have run a paired sample t-test to study the effect of the intervention on individual investment rates, using pre and post-intervention investment rates, as in our Wilcoxon signed rank tests. We would also have tested the intervention effect by conducting an independent-samples t-test, by comparing mean high-tech sector investment rates in our no intervention game against intervention games, for both the in-class and out-of-class groups (given more participants we would have conducted an out-of-class high government intervention game).

We think our findings warrant further experimental research into the conditions under which a big push may be successful. Firstly, research could delve more deeply into cultural differences in investment rates, a major finding of our study. We feel that this could be done through recruitment of a more internationally representative sample, with a particular emphasis on recruiting subjects from developing countries. Furthermore, we propose providing participants with information on the nationality of the other group members, with treatments varying according to the national composition of participants i.e. homogeneous and mixed nationality sessions. This kind of research would provide an insight into countries in which the impact of big push policies might be limited, for example because of ethnic rivalries that induce a lack of trust, and the role that foreign investors could play in the development of new industries. Furthermore, countries in which trust is low might require the government to play a coordinating role that extends beyond reducing the financial risk involved in transitioning to new industry, for example, through administrative guidance.

We also think our game, given a larger sample size and additional treatments varying the intervention size to a smaller degree, could be used to study the impact of differences in the size of big push policies on the likelihood of cooperating on the high-tech equilibrium. Unfortunately, our results did not allow us to shed light on this aspect, but it has profound policy implications. Lastly, it would be useful for further research to pursue an experimental approach that is capable of differentiating between the risk-aversion and trust mechanisms driving investment rates, since policy implications are likely to differ depending on the importance of the two mechanisms in a given sample.

We find limited evidence in support of the growth-enhancing benefits of big push theory, however, combining further experimental research with empirical evidence based on case studies, which is currently limited, will be necessary to strengthen the evidence base for big push theory. If we are to believe the essence of big push theory, many of the piecemeal investments currently undertaken in developing countries represent a waste of scarce resources. Instead, these countries would benefit from large-scale industrialisation policies, which might warrant a short-term increase in foreign aid, as advocated by Sachs. If a big push is a viable way of driving an economy out of a poverty trap, big push policies could drag hundreds of millions of people out of poverty in the matter of a few decades, perhaps with a lower long-term cost than that associated with gradual government investment.

Some development economists would heed caution to the idea a large expansion of foreign aid can help transform developing countries. Industrial policy may suffer from government failure due to factors such as a lack of information (e.g. the government may be unable to select the most profitable sectors to support) and corruption. Furthermore, coordination of industrial activity depends on the credibility of the investment environment, since investors must believe the government will sustain its policies for a period long enough to make investment profitable. Given there is likely to be a lag between government intervention and economic growth, investors may be worried that external financing, be it through foreign aid or debt, will dry up before the government is able to complete its investment package.

Critics of aid might therefore argue that providing more aid to countries with weak institutions will only serve to further waste resources, and that institutional change must precede grand government investment plans. Aid targeting, however, may be a way around some of these concerns, and a viable method through which big push policies can be funded.

8 Conclusion

We find some evidence to support the idea that a big push policy can ease coordination problems in the presence of multiple equilibria, driving the economy towards a higher growth path. We also observe cross-cultural differences in risk aversion and/or levels of trust, potentially affecting the viability of big push policy. The conditions under which big push policy is likely to be successful is a promising area for further research, both in an empirical and experimental setting.

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A Appendix

Information screen

Welcome!

The following experiment is an interactive game. The game will last up to 30 minutes, but the number of periods of the game is indefinite i.e. it is possible the game may be much shorter than 30 minutes.

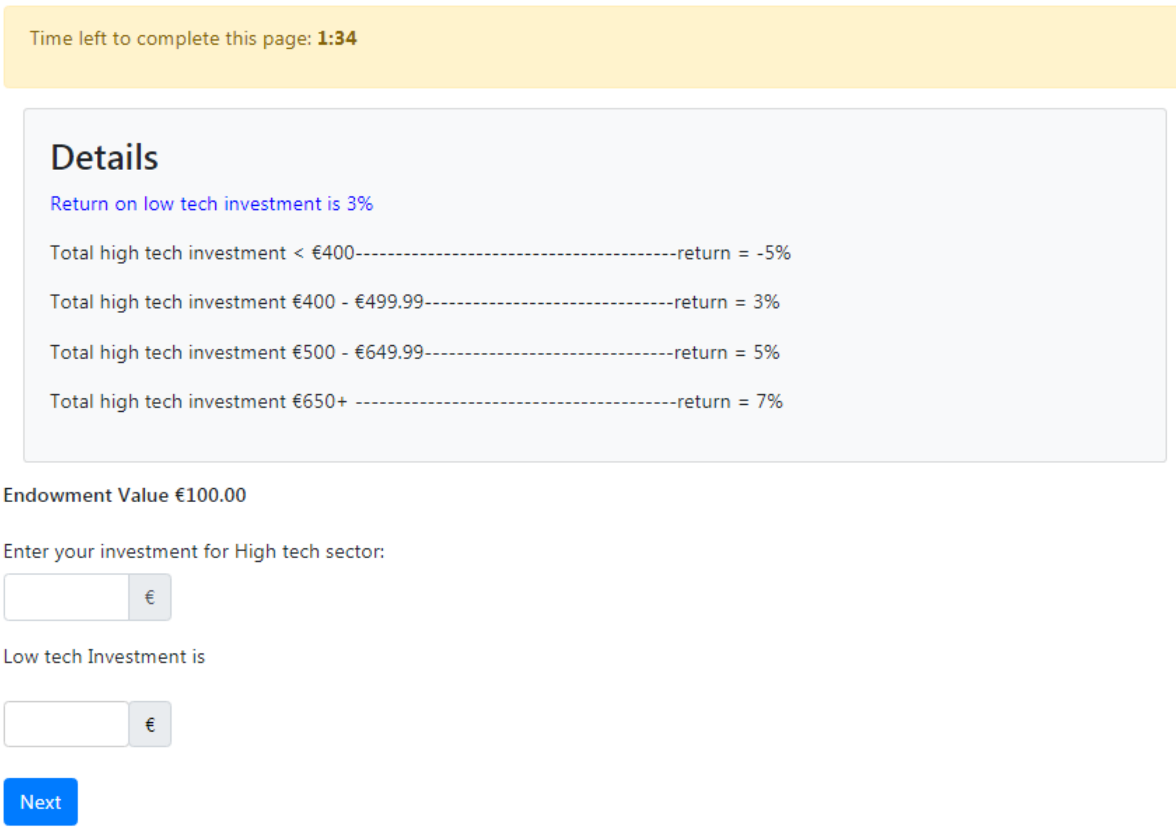
You will be part of a virtual economy of 7 players. You will be asked to make an investment decision in which you must allocate your endowment between investment in a low-tech sector and investment in a high-tech sector. All players have the same endowment. Your endowment will change each round - you will play each round with your endowment + the value of your accumulated profit (or loss) from previous rounds.

Investment in the low-tech sector guarantees a sure return, whereas, the return in investment from the high-tech sector depends on the total investment in the high-tech sector from all the players. This is because there is interdependence in the production process and production is produced under increasing returns to scale. Therefore, is a threshold level of total investment in the high-tech sector below which you will earn a negative profit. You will be provided with a payoff structure detailing the % return associated with each possible level of total investment by all players in the high-tech sector. If the total investment is below a certain threshold, the return will be negative.

Your final payoff will be determined by your total earnings after the final period of the game.

Your answers are anonymous and will not be known to other members of the group. Please answer as if you were investing your own money.

Figure 1: Instructions


Time left to complete this page: **1:34**

Details

Return on low tech investment is 3%

Total high tech investment < €400--return = -5%

Total high tech investment €400 - €499.99-------------------------------return = 3%

Total high tech investment €500 - €649.99-------------------------------return = 5%

Total high tech investment €650+ --return = 7%

Endowment Value €100.00

Enter your investment for High tech sector:

€

Low tech Investment is

€

Next

Figure 2: No government intervention payoffs

Please wait

Waiting for other participants to contribute.

Some interesting facts for you

It can take a photon 40,000 years to travel from the core of the sun to the surface, but only 8 minutes to travel the rest of the way to earth

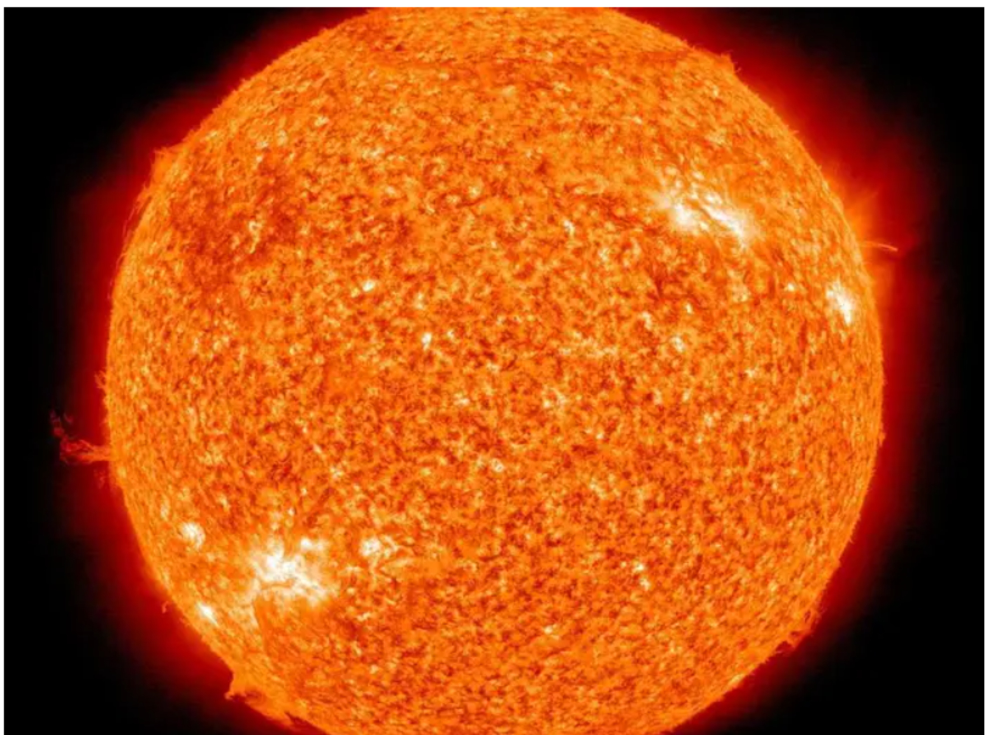
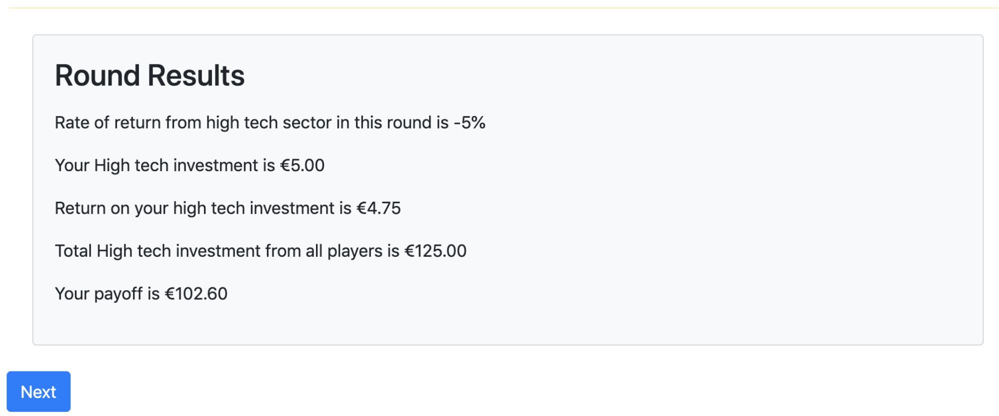


Figure 3: Fact page



Round Results

Rate of return from high tech sector in this round is -5%

Your High tech investment is €5.00

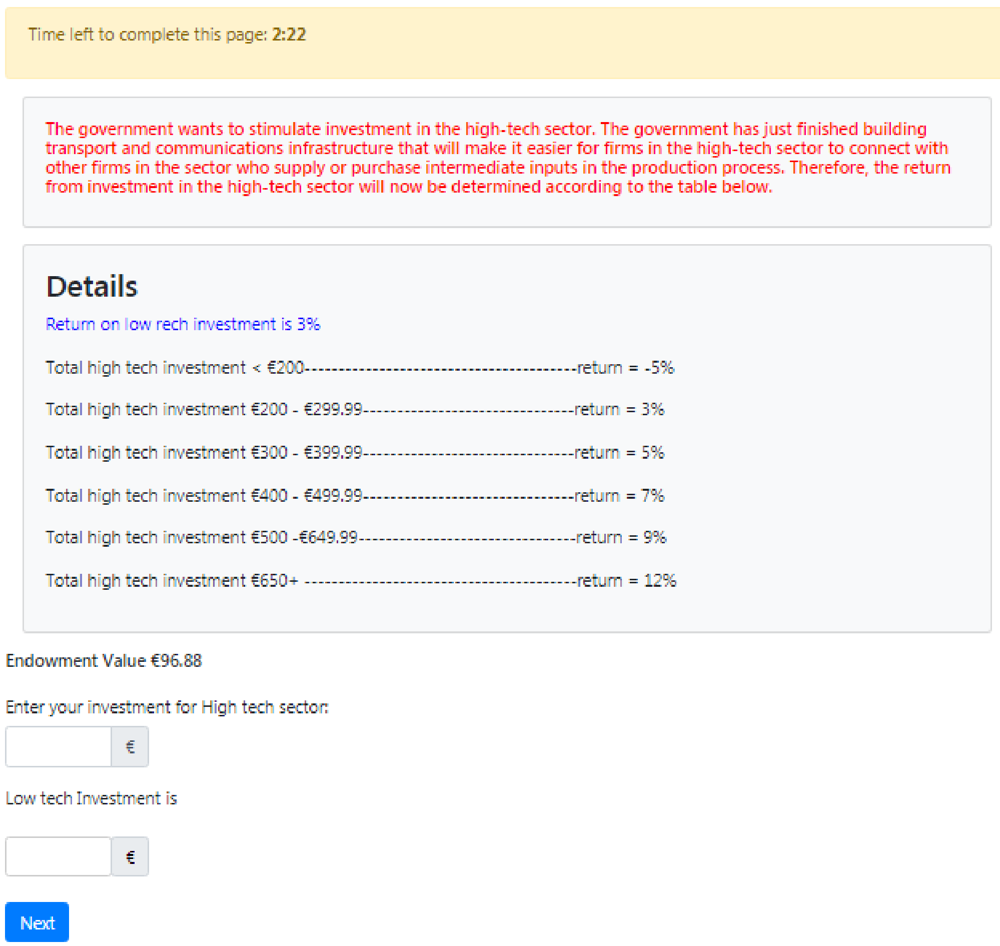
Return on your high tech investment is €4.75

Total High tech investment from all players is €125.00

Your payoff is €102.60

Next

Figure 4: Returns page



Time left to complete this page: **2:22**

The government wants to stimulate investment in the high-tech sector. The government has just finished building transport and communications infrastructure that will make it easier for firms in the high-tech sector to connect with other firms in the sector who supply or purchase intermediate inputs in the production process. Therefore, the return from investment in the high-tech sector will now be determined according to the table below.

Details

Return on low rech investment is 3%

Total high tech investment < €200--return = -5%

Total high tech investment €200 - €299.99------------------------------return = 3%

Total high tech investment €300 - €399.99------------------------------return = 5%

Total high tech investment €400 - €499.99------------------------------return = 7%

Total high tech investment €500 -€649.99-------------------------------return = 9%

Total high tech investment €650+ ---------------------------------------return = 12%

Endowment Value €96.88

Enter your investment for High tech sector:

€

Low tech Investment is

€

Next

Figure 5: Intervention payoffs following government intervention - high government intervention game

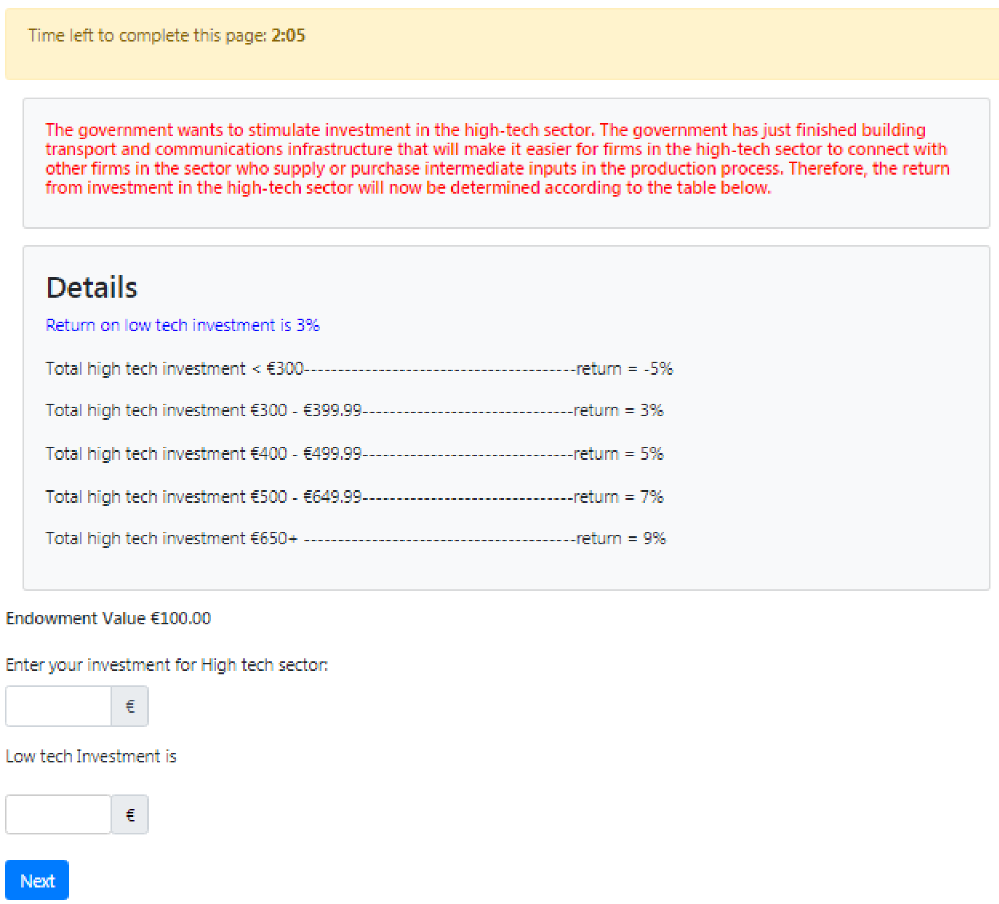


Figure 6: Intervention payoffs following government intervention - low government intervention game

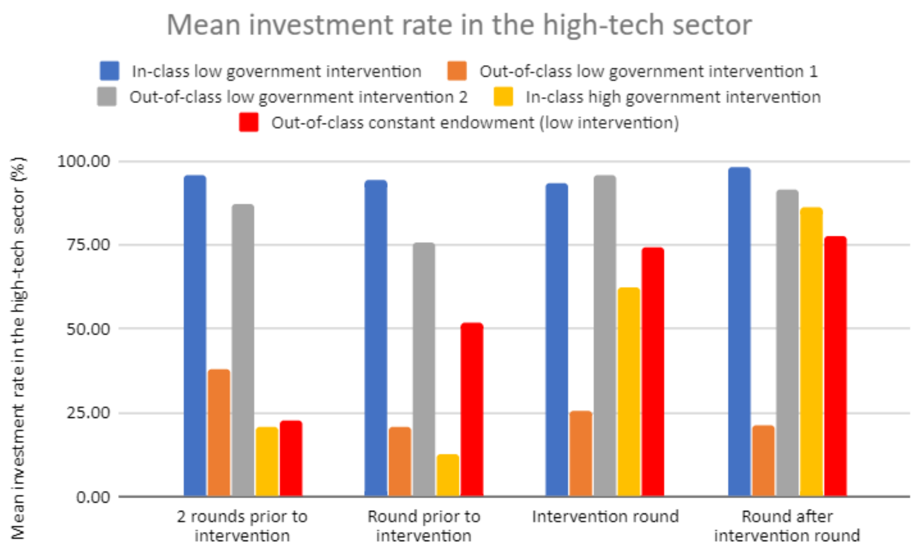


Figure 7: Mean investment rates surrounding the intervention

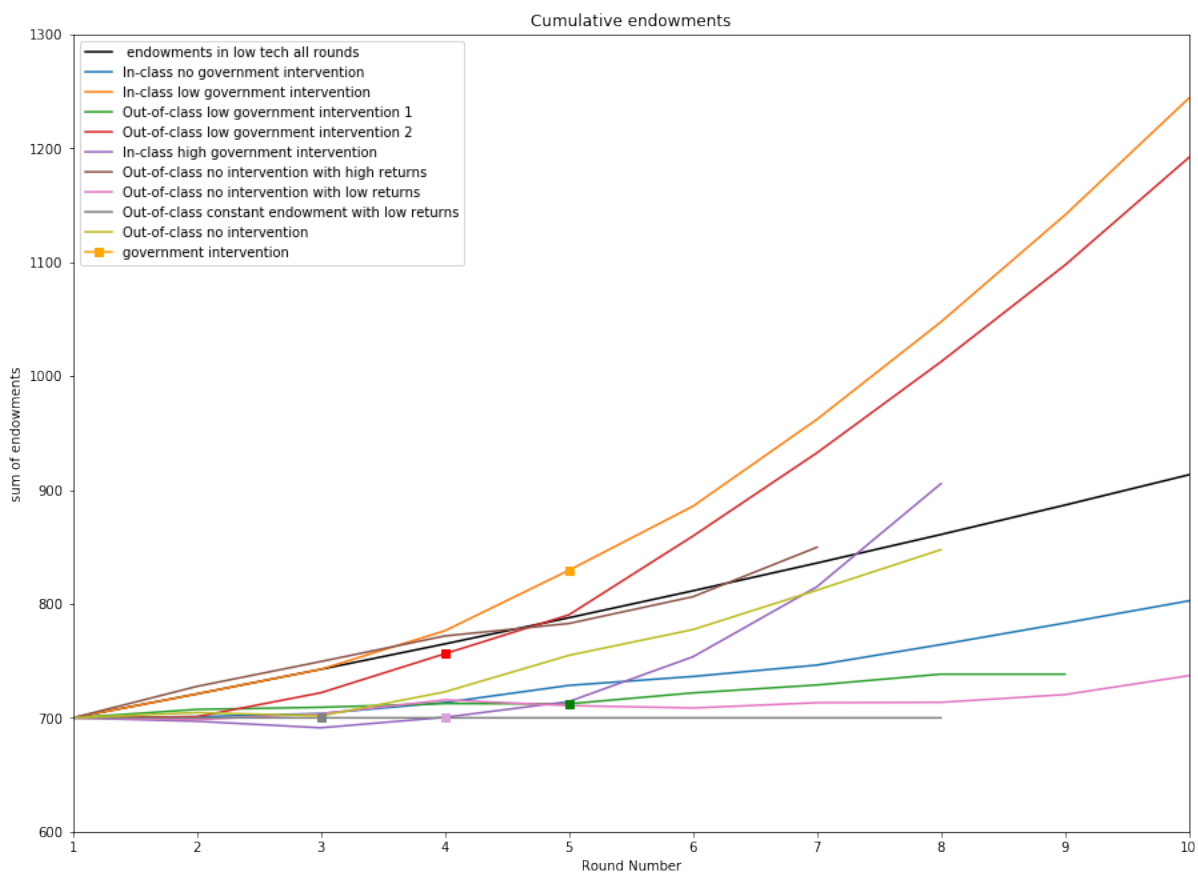


Figure 8: Escaping the poverty trap

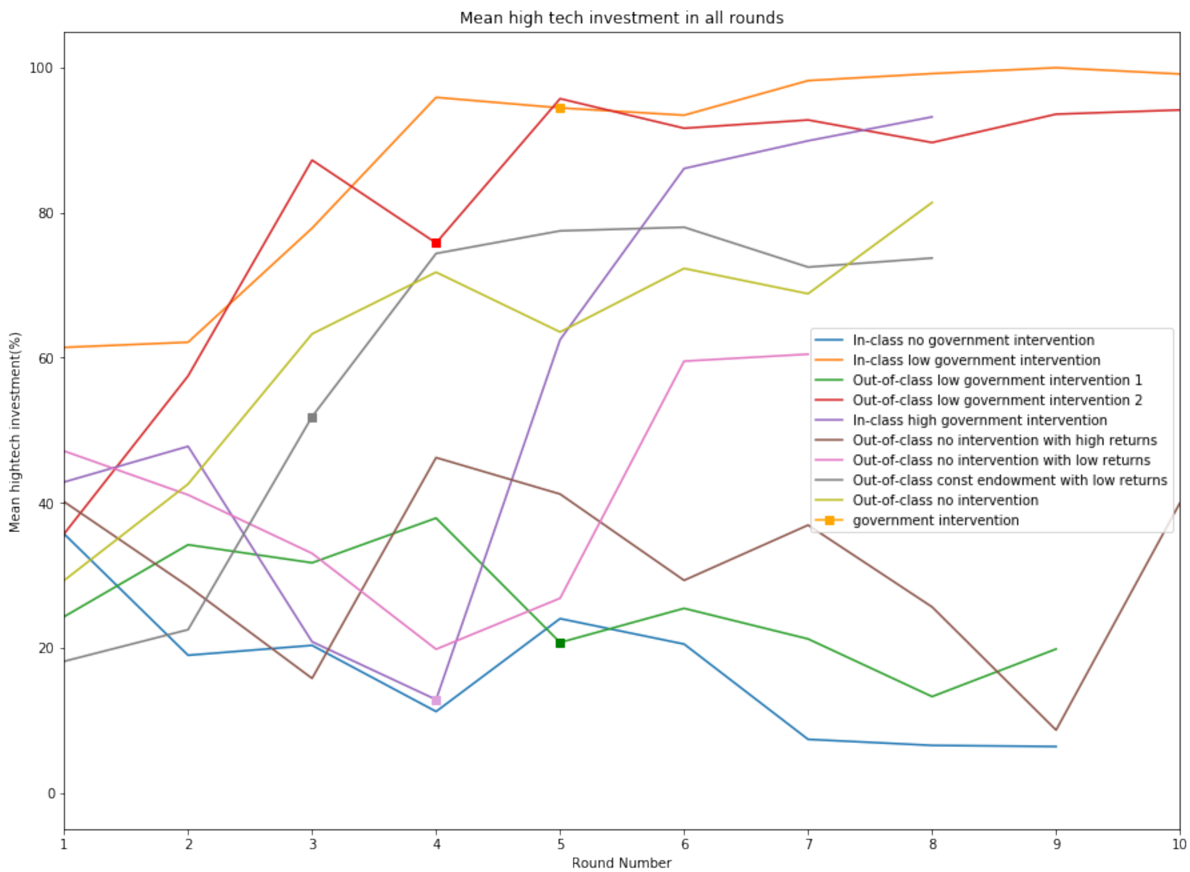


Figure 9: Mean high-tech sector investment across all rounds

VARIABLES	(1) Meaninvestmentinhightechsec
Age	0.709
	(2.223)
Male	-1.193
	(8.874)
SouthernEuropean	-8.392
	(7.332)
lowint	72.62***
	(8.502)
highint	43.40***
	(9.157)
Constant	3.470
	(51.96)
Observations	21
R-squared	0.852

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Figure 10: In-class regression analysis

VARIABLES	(1) Meaninvestmentinhightechsec
Male	-3.234
	(7.569)
Age	0.0132
	(0.304)
Indian	-56.99***
	(10.08)
Othernationality	-6.245
	(13.29)
noint	-23.56**
	(10.77)
highreturns	17.66*
	(8.920)
lowreturns	-2.592
	(8.653)
constantendow	-18.65
	(11.28)
Constant	87.30***
	(9.580)
Observations	41
R-squared	0.698

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Figure 11: Out-of-class regression analysis

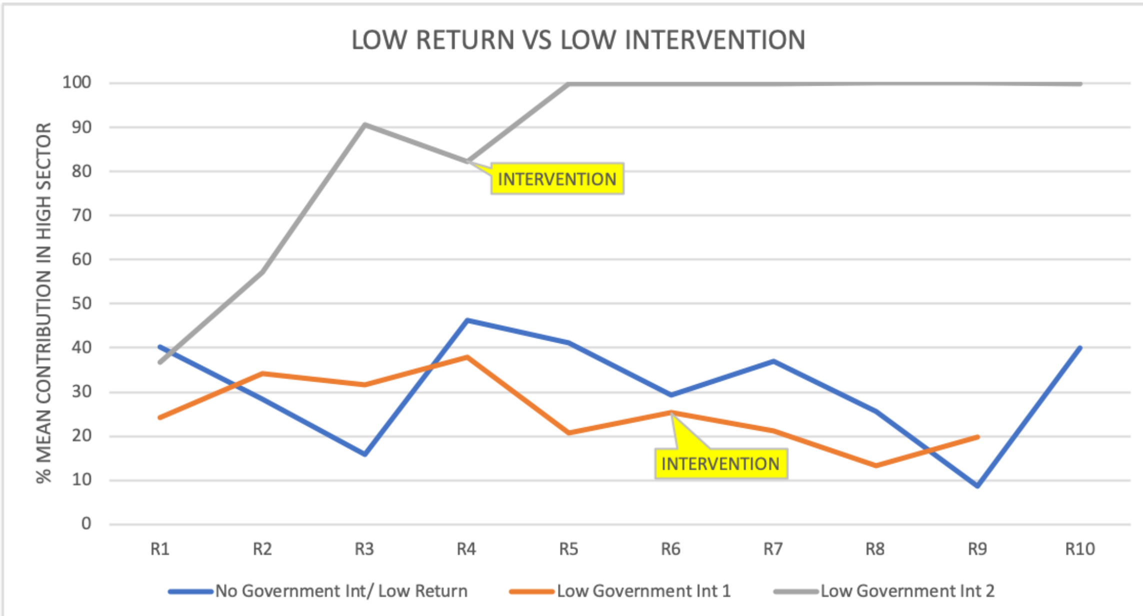


Figure 12: Intervention effect with low payoffs

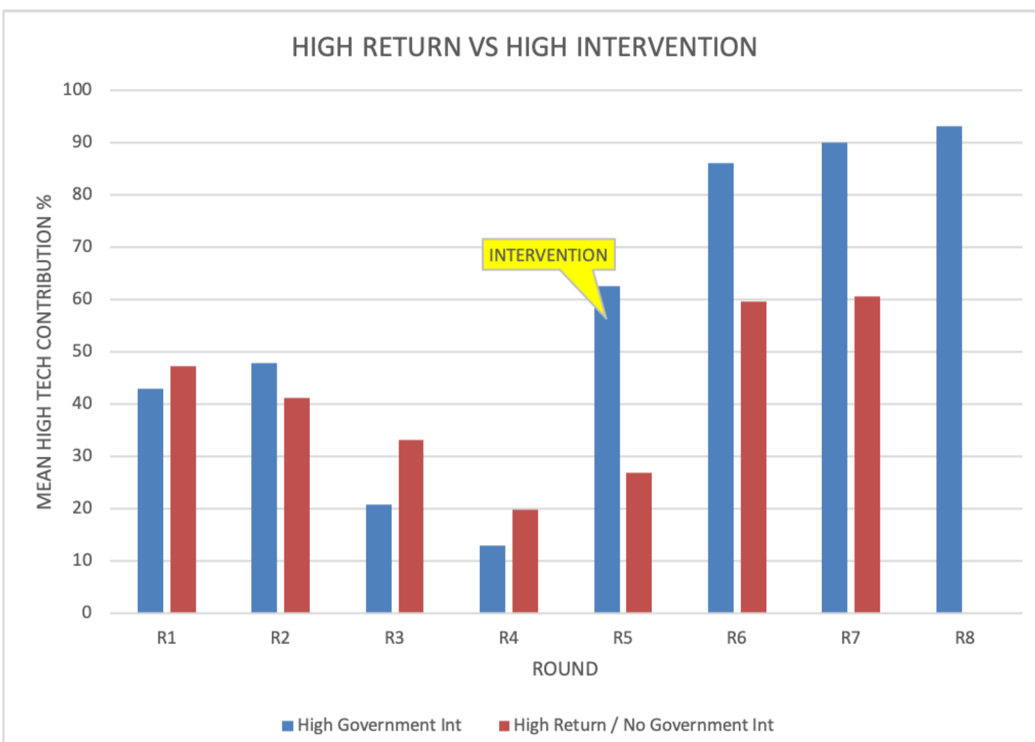


Figure 13: Intervention effect with high payoffs